

# **Dynamics of Area and Production of Major Pulse Crops in India**

भारत में प्रमुख दलहन फसलों के क्षेत्र और उत्पादन की गतिशीलता

**HARKESH KUMAR BALAI**

**Thesis**

**Doctor of Philosophy in Agriculture**  
(Agricultural Economics)



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**DEPARTMENT OF AGRICULTURAL ECONOMICS AND MANAGEMENT  
RAJASTHAN COLLEGE OF AGRICULTURE  
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY  
UDAIPUR-313001 (RAJASTHAN)**

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*Thesis*

*Submitted to the*

*Maharana Pratap University of Agriculture and Technology, Udaipur*

*in partial fulfilment of the requirements for*

*the degree of*

***Doctor of Philosophy***

*in the*

*faculty of Agriculture*

**(Agricultural Economics)**



**BY**

**HARKESH KUMAR BALAI**

**2021**

## **CERTIFICATE –I**

### **CERTIFICATE OF ORIGINALITY**

The research work embodied in the thesis titled “**Dynamics of Area and Production of Major Pulse Crops in India**” submitted for the award of degree of **Doctor of Philosophy (Ph.D.)** in Agriculture in the subject of **Agricultural Economics**, to Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), is original and bonafide record of research work carried out by me under the supervision of **Dr. Hari Singh** (Incharge Head and Assistant Professor), Department of Agricultural Economics and Management, Rajasthan College Agriculture, Udaipur). The content of the thesis, either partially or fully, have not been submitted or will not be submitted to any other institute or university for the award of any degree or diploma.

The work embodied in the thesis represents my ideas in my own words and where others’ ideas or words have been included. I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the university and can also evoke panel action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Place: Udaipur

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(Harkesh Kumar Balai)

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# 1. INTRODUCTION

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One of the most important segment of Indian agriculture after oilseeds and cereals is pulse production. The pulses comprise Chickpea, Pigeon pea, Lentil, Green gram, Black gram and Field pea. Being an important crop commodity they provide high quality protein. Moreover they complement other cereal crops thus helping the population of the country by providing nutritious diet. 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 (Singh *et. al.*, 2016).

The Food Security Act-2013 mandatorily contemplates the right to nutritional security as well the govt.’s to priority is to ensure access to sufficient quantity of highly nutritive and quality food at affordable prices to each individual. This is as per the Food and Security Act of 2013. Pulses can be considered as an important group of crops as they are highly nutritious. They can play an important role in the enhancement of national food and nutritional security of the country. Pulses are also capable of taking upcoming and changing environmental challenges. About 9-10 per cent share is of the pulses to the total food grain having important and valuable plant based proteins, vitamins and minerals. As they are inexpensive and protein rich they form an essential part of the meal about 20-25 per cent. Pulses are also useful from health point of view helping fight, malnutrition, diabetes etc. Pulse – wise nutritional status is given in Table1.1

**Table 1.1: Crop – wise nutritional status of Pulses**

(Unit-mg/100g)

S. No.	Name of Food Stuff	Gram	Black Gram	Green Gram	Lentil	Pigeon pea
1.	Protein (%)	20	24	25	25	22
2.	Vit. A (I.U.)	316	64	83	450	220
3.	Vit. C	3	-	-	-	-
4.	Vit. K	0.29	0.19	-	0.25	-
5.	Thiamine	0.3	0.41	0.72	0.45	0.45
6.	Ribo-flavin	0.51	0.37	0.15	0.49	0.51
7.	Nicotinic-acid	2.1	2	2.4	1.5	2.6

S. No.	Name of Food Stuff	Gram	Black Gram	Green Gram	Lentil	Pigeon pea
8.	Biotin (g/100g)	10	7.5	-	13.2	7.6
9.	Choline	194	206	-	299	183
10.	Folic-acid (g/100g)	125	144	-	107	83
11.	Inositol	240	90	-	130	100
12.	Pantothenic-acid	1.3	3.5	-	1.6	1.5
13.	Total No. of Vitamins/ Minerals	12	11	5	11	10

(Source: Ministry of Agriculture and Farmers Welfare, DAC and FW, 2018)

In India, it has been found that most of the population, be it vegetarian or non-vegetarian are dependent on pulses for protein source. Pulses are cheaper as compared to animal protein and therefore more in demand. It is also referred to as poor man's meat in developing countries like India. When compared to superior cereals like Wheat and Rice it has been observed that Gram, Black gram and lentil contains 20, 24 and 25 per cent of proteins whereas Wheat and Rice contains only 11.8 and 8.5 per cent respectively. Red gram is popularly known as arhar, Green gram known as moong, Bengal gram known as Chana, Lentil is known as masoor, and Black gram is known as urd. Pulses possess additional value and are used in the preparation of south Indian dishes, sweets and papads. It is also served as fodder to the milch cattle due to its highly nutritive value. Dal, the split grains prove to be an excellent source of high quality and nutritive protein, amino acids, fiber, minerals and vitamins along with acting as green maturing crop, the help to increase the nitrogen status of soil meeting up to 80 per cent of the nitrogen requirement. Less amount of water requirement compared to the cereals crops about 1/5<sup>th</sup> helps in saving the water requirement for the irrigation. Thus, it serves as an integral part of the crop production especially in the dry areas allowing more scope for crop diversification.

Recently it was found that the per capita consumption of pulses in some regions, especially Asia and sub Saharan Africa registered stagnation and steep decline. This perhaps was due to the change in the preferences of the consumers. Meanwhile some countries showed failure in the domestic production upto zero level. Contrary to this in developed countries, it is consumed in lesser amount, and more

being used for export. However due to enriched health benefits and international migration, the per capita consumption has shown increasing trend. It is estimated that the food production must increase by about 5 million tones annually. This is due to the fact that the plant protein (pulses) are consumed more as compared to animal protein due to more potential thereby increasing its demand (Food outlook – FAO 2016).

As per the report of the Working Group on Crop Husbandry, demand and supply projection for XII plan (2012-17) of NITI Aayog (erstwhile Planning Commission), the demand of pulses at 3.09 per cent per annum growth during 2016-17 and 2017-18 has been worked out at 22.74 Mt and 23.44 Mt, respectively.

Pulses prove to be a boom for mankind as they are highly nutritive important gift of nature. They not only increase the fertility of the soil by nitrogen fixation but also increase the porosity of the soil due to their invasive top root system due to the low requirement of water and ability to withstand serves revealed that decline in pulses consumption lead to increase in malnutrition due to decline in protein intake. (Shalendra *et al.*, 2013). India is still a home for about 24 per cent of under nourished people in the world (Sharma *et al.*, 2016 and Ahlawat *et al.*, 2016).

According to FAO study on the state of food security and nutrition in the World-2017, about 190.7 million people are undernourished in India. Further, this measure indicated that 14.5 per cent of total population is still undernourished in India. On account of these virtues and its importance for human health, the United Nation declared 2016 as “International Year of Pulses”. India has been distinguished of being one of the major pulses producers, importers and consumer countries, contributing about 29 and 30 per cent to the global pulse production and consumption, respectively. Following these attributes the per capita availability of pulses in India was 54.5 grams/capita/day in 2017-18 which was lesser than the recommended intake of 65 grams/capita/day as per ICMR and RDA schedule. Pulses play an important part of Indian agricultural economy next to the food grains and oilseeds in term of acreage, production and economic value (Singh *et al.*, 2016).

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). India is the largest producer,

consumer and importer of the pulses in the world. India was the largest producer (25%), consumer (27%) and importer (14%) of pulses in the world. (Mohanty and Satyasai, 2015).

Although rich natural resource is available in India, pulses can be produced with a minimum use of resources and hence, it becomes less costly even than animal protein sources. Pulses are mostly cultivated under rainfed conditions and do not require intensive irrigation facility and this is the reason why pulses are grown in areas left after the demand for cereals/cash crops is met with. However the gap between supply and demand is recurring which has raised issue concerns resulting in price high and hereafter inaccessible to the poor. The sluggish performance of pulses production in the region and at the national level has resulted in increasing deficit, on the one hand and depletion of foreign currency reserves by soaring import bills, unpredictable price rise and lower net profit compared to competing crops, on the other hand (Srivastava *et al.*, 2010).

Import of pulses has fallen by 3 million tones in the financial year 2018. However with the growing awareness among the utilizers, the demand for pulses has shown an increase. Although India is amongst the largest producers of pulses. It is also the largest importers and consumer in the world (23-24 million tones).

Due to drought and irregular behavior of rainfall across the pulse growing states in the country, the year 2014-15 and 2015-16 were considered as adverse crop years. By enhancing the import between the year 2014-2015, the government has ensured the availability/supply at about 5-6 million tones/years in their buffer stock as well as taken action to fight against natural calamities. This has been done through development programmes, PSS and PSF procurement as well as risk management through PMFBY.

In order to safeguard the inherent of the farmer, export of pulses was allowed. The approval for removal of prohibition of export of all levels of pulses was recently given by the Cabinet Committee on Economic Affaire (CCEA). This has helped the farmer to have greater choice market their produce and there gain better remuneration for their produce.

The government lifted the ban on export of tur, urad and moong dal on 15<sup>th</sup> Sept, 2017 followed by the above decision taken the shipment of these varieties was

allowed only through permission from APEDA, the agriculture export promotion body permission to export organic pulses and Kabuli chana was however limited. Granting export of all types of pulses would help in creating market buoyancy as well as open access to global market. It would also help the farmers to fetch remunerative prices by disposing their products along with encouraging them to expand the sowing area.

Almost 50 per cent of world pulse output is concentrated in Asia (India, Myanmar, China and Turkey), followed by 22 per cent in Africa (Nigeria, Tanzania, Niger and Ethiopia), 19 per cent in the America (Canada, Brazil, USA and Mexico), 9 per cent in Europe and the remaining 4 per cent in Oceania. Low Income Food Deficit Countries (LIFDCs) account for 48 per cent of world production and Least Developed Countries (LDCs) about 23 per cent substantiating the importance of these crops in the most economically disadvantaged countries. As per the data for the past 30 years is concerned, India finds its place in doubly as the largest producer of pulses, consequently producing two-three times more than any other country. (Food outlook, biannual report 2016, Food and Agriculture Organization).

The pulses crop was cultivated over 85.40 million hectares along with 87.40 million tones 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) but chickpea production has made it a leading crop amid other pulse crops in the world. Chickpea, pigeon pea and lentil are major contributing crops in total world pulses production with the share of 16.69, 10.40 and 17.72 per cent, respectively (Anonymous 2018).

India is known to be the largest producer (25.23 million tones), consumer (23-24 million tones) and importer (5-6 million tones) of pulses in the world (Anonymous, 2018). It secured the top position in area and production with 35 per cent and 29 per cent in the world respectively. India plays a significant role in the world pulse market. In India food grains occupy 65 per cent of total gross cropped area comprising cereals in 50 per cent and pulses in about 15 per cent. Within pulses, gram occupies 5 per cent area followed by black gram 3 per cent, pigeon pea 2 per cent and green gram 2 per cent. Other pulses cover about 3 per cent of gross cropped area. Under individual crop category, gram with 46 per cent production share in total pulses is the highest contributor followed by Pigeon pea 17 per cent, black gram more

than 13 per cent and green gram 8 per cent. The total area coverage and production of kharif pulses during 2017-18 has been 138 Lha and 90 Lt, 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. All India rabi pulse acreage was 150 Lha and production was 154 Lt. Madhya Pradesh ranked 1<sup>st</sup> with 30 per cent of area and 37 per cent of total rabi pulse production in the country (Anonymous, 2018).

Pulses were cultivated over more than 29 million hectare area with productivity of 841 kg/ha. Ten states were the major producers contributing more than 90 per cent pulses. These were Madhya Pradesh (> 8 mt), Rajasthan (>3 mt), Maharashtra (>3 mt) Uttar Pradesh (>2 mt) Karnataka (2 mt) and Andhra Pradesh (>1 mt) producing more than one million tones each followed by Gujarat, Jharkhand, Tamil Nadu, and Chhattisgarh producing <1.0 mt each (Anonymous, 2018). Under individual crop category, gram recorded a highest ever production of 11.23 mt at a record productivity level of 1063 kg/ha in an area of 10.56 million hectares. Major 07 states that contributed > 90 per cent in gram production have been Madhya Pradesh (4.60 mt), Maharashtra (1.78 mt), Rajasthan (1.67 mt), Karnataka (0.72 mt), Andhra Pradesh (0.59mt), Uttar Pradesh (0.58 mt) and Gujarat (0.37 mt) (Anonymous, 2018). Pigeon pea remained at second position in total pulse production with 4.25 mt under acreage of 4.43 million hectare with the productivity of 960 kg/ha, the ever highest yield. Major states to record the success had been Maharashtra (1.07 mt), Madhya Pradesh (0.84 mt), Karnataka (0.77 mt), Gujarat (0.34 mt), Uttar Pradesh (0.33 mt), Telangana (0.26 mt) and Jharkhand (0.22 mt). Urad (Black gram), showed to be the 3<sup>rd</sup> important pulse crop which was cultivated over an area of 5.44 million hectare (kharif + rabi) and recorded a production of 3.56 mt at a productivity level of 655 kg/ha. Major contributing states had been Madhya Pradesh, Rajasthan, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Maharashtra, Jharkhand and Gujarat. Similarly, green gram was introduced as 4<sup>th</sup> important pulse crop which was sown over an area of 4.26 million hectare (kharif + rabi) that recorded a production of 2.01 mt and yield level of 472 kg/ha. Rajasthan, Madhya Pradesh, Maharashtra, Karnataka, Bihar, Andhra Pradesh, Odisha, Tamil Nadu, Gujarat and Telangana had been the major green gram producing states. Lentil was also introduced as 5<sup>th</sup> important pulse crop and recorded production of 1.61 mt from an area of 1.55 million hectare at a

productivity level of 1034 kg/ha. Leading six lentil producing states had been Madhya Pradesh (0.68 mt), Uttar Pradesh (0.50 mt), West Bengal (0.15 mt), Bihar (0.14 mt), Jharkhand (0.06 mt) and Rajasthan (0.03 mt) (Anonymous, 2018).

Decomposition analysis in agricultural output has remained an important part of interest to researchers and policy makers. A breakdown of growth into various component, area and yield, facilitates in output projection with alternative targets and policies (Jamal and Zaman, 1992). Thus, decomposition of agricultural growth among its constituent forces is of great importance. The pulses production has virtually come to a standstill over the last 40 years mainly because of two reasons. Firstly, 87 per cent of the area under pulses is rainfed. The second reason is that, after diverting the better-irrigated lands for higher yield-higher input crops like rice and wheat. The pulses are grown as residual crop on marginal land. Due to lack of effective procurement and risk of yield and price, farmers are not motivated to cultivate/grow pulses. Again pulses have more susceptibility towards pest and insect as compared to rice and wheat and face several biotic and abiotic stresses. As compared to demand and lower production in both domestic and global markets have led to a steep rise in prices of pulses.

Stagnant pulses production between 15 and 25.23 million tones with significant growth was observed in the country between 2010 and 2017. Even after the production of the highest quantity of pulses, import would become necessary in order to bridge the gap between demand and supply. To meet the domestic demand, the country is importing about 5–6 million tones pulses. The growth rate of pulses production was stagnant as compared to population growth rate of 1.44 per cent and has led to progressive decline in per capita availability of pulses (Anonymous, 2018) the last decade has seen, a progressive decline in pulse consumption, especially among the poorer segments of the population due to high purchase prices.

Seasonal price movements tied to the seasonal nature of the crop cycle has been exhibited by the pulses. During harvest crop prices are lower in the spot and future markets. Due to supply pressure on the other hand, they are usually the highest by the end of the marketing season when supplies are less abundant. Seasonal price patterns can be used as a guide for developing a marketing plan when they are examined along with supply and demand information. Proper planning can be done about selling a portion of the crop produce in spot market or future market. Price

analysis is the study of past price movements and the supply and demand factors associated with them. Price analysis, thus, explains how and why prices have behaved in a particular manner as well as whether there is consistency in the price behavior of commodities over time and space.

Agricultural commodities possess more or less uniform price trend overtime due to seasonality in nature and price behavior is mainly based on the traditional theory of supply and demand conditions. Due to seasonal behavior of agriculture, it is observed that during peak arrivals, the prices would be low and vice versa. However, the demand is spread throughout the year. In these circumstances, the validity of the determination of price of an agricultural commodity based on aggregate demand and supply conditions at a given time is uncertain. In fact, this results in a hazardous situation leading to an imperfect pricing system, in which either final consumer or final producer or both would be adversely affected.

Generally, arrivals are more in the production season in the producing areas and lesser in the other seasons. Its market arrivals and prices exhibit a seasonal pattern. The season based production causes fluctuations in prices from one season to the other. The fluctuation in prices causes wide variation in the income of pulses growers from season to season and year to year.

The present study was undertaken to measure the growth and instability (area, production and yield), decomposition and price behavior dynamics of pulses, which would helpful to understand the whole dynamics of pulses in India. The present study will also help the policymakers and government for planning and implementation of policy issues as related to pulse production and marketing.

Therefore, looking to the importance of pulse crops for the producers as well as consumers, the present study entitled “Dynamics of Area and Production of Major Pulse Crops in India” had been under taken with the following specific objectives:

### **OBJECTIVES**

- i. To estimate the trend in area, production and productivity of pulse crops in India.
- ii. To estimate the relative contribution of acreage and yield in production of pulse crops over time.

- iii. To measure instability in area, production and productivity and to determine the causes of instability, and
- iv. To analyze the seasonal price behavior of major pulse crops.

### **LIMITATIONS OF THE STUDY**

Though all possible efforts were made to make the study objective and precise but due to the paucity of time at the disposal of investigator, certain limitations did still remained in the study, which are as under mentioned:

- (i) The study was based on secondary sources of data and hence the accuracy of results depended on the accuracy with which the secondary data were generated.
- (ii) Due to lack of data of area, production and productivity of lentil crop in Karnataka state, it was not included in study.

### **PLAN OF THE THESIS WORK**

The study has been presented in five chapters. Chapter first deals with introduction, importance, objectives and limitations of the study. The chapter second enlisted the review of the literature which is grouped under four sections namely those related to trend, decomposition, instability and seasonal behavior of selected pulse crops. The third chapter on materials and methods briefly describes the pulse crops selected for the study, the types of data used for investigation, coverage and also the analytical techniques. The chapter fourth is meant for results and discussion which has been classified under different heads. Summary and conclusion of the study has been presented in chapter fifth and bibliography has been given at the end.



## 2. REVIEW OF LITERATURE

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The literature when reviewed provides a theoretical framework which will be very useful in executing the research, starting from raising an issue to the final conclusion. There by, a comprehensive survey of the earlier work done is very much essential in framing the objectives of a current research problem. The available literature has been grouped into following four sub headings:-

### 2.1 Area, production and productivity of pulse crops

**Singh (1996)** analyzed the growth rate of area and productivity of pulse crops in Bihar. Data collected from various books, journals and monthly bulletins for the period 1968 to 1990 were used to examine the growth rate of area, production and productivity of pulse crops in Bihar. During the period, acreage devoted to the production of gram, tur, peas and khesari decreased, while that of masoor remained unchanged and moong beans increased. Productivity increased in all crops over this period.

**Mundinamani et al. (1998)** worked on economic analysis of growth rates in area, productivity and production of pulses in Karnataka. The growth rates in area, yield and production of total pulses, and of red gram, at district level in Karnataka, India, over the period 1970-71 to 1984-85 were presented. Growth rates remained almost stagnant at state level, but three districts registered positive growth rates in area, yield and production.

**Singh and Chandra (2001)** analyzed growth trends in area, yield and production of paddy, coarse cereals, pulses and oilseed at all India level for the period of 1975-1998. The analysis revealed that higher growth rate in production of paddy and a coarse cereal had been due to increase in yield while, in wheat it is due to increase in area and yield. In case of cereals, the growth in production had been low. In pulses, negative growth rate in area under gram crop and negative growth of yield in pigeon pea had been observed.

**Kalamkar (2001)** conducted a study on Agricultural development and sources of output in Maharashtra stste. The study was based on time series secondary data from 1961-62 to 1997-98. The compound annual growth rate was calculated by using log linear model. Results indicated that positive and significant compound annual

growth in area, production and productivity of total pulses were found to be 1.05, 3.96 and 2.13 per cent during the entire study period.

**Naik and Thimmappa (2001)** computed growth rates of area, production and yield of principal crops in India during the period of 1979 to 1999. The production growth of food grains was found to be negative in the nineties due to composite effect of negative growth rate in area and low growth rate in productivity. The growth rate of production of pulses in nineties was lower as compared to the eighties due to the negative growth rate in both of the pulses area as well as slower productivity growth. In case of oilseeds, the annual growth rate in production and yield declined during nineties over eighties.

**Pandey (2001)** studied temporal growth changes in production of main crops in Haryana for the period of 1956 to 1999. Estimation on trend and annual growth rates in area, production and yield of main crops was done by the linear regression equations. The study revealed that the state witnessed a substantial increase in production of wheat, rice, cotton (American) and rapeseed and mustard during the period under study mainly due to improvement in the production technology and prevalence of remunerative market prices.

**Ramasamy and Selvaraj (2002)** attributed the slow growth in pulses production for low growth in yield. The very smaller area under irrigation and its variability contributed for instability in pulses production. Lack of knowledge on crop management and technological constraints such as the insufficient and untimely availability of high yielding varieties (HYVs) of seeds affected pulses production. The differential impact of technologies, high yielding varieties and irrigation substantially affected area under pulses. Relative decrease in instability of paddy and wheat yield drastically affected pulses (Report on Expert Committee on Pulses, 2012).

**Kumar and Gupta (2004)** studied growth rate and income stability of soybean in different agro climatic zones of Madhya Pradesh. This study examined the growth rates of area, production and yield of soybean. In aggregate, results indicated that both area and production growth were highly significant while yield growth was very small and insignificant.

**Sharma (2004)** analyzed trends of area, production and productivity of food grains in North Eastern States. The study was based on secondary data from 1980-81

to 2001-02. The data was collected from several government publications and web sites. To analyze the trend of area, production and productivity of food grains in north eastern states, the linear, quadratic and exponential functional forms were used. To fit the trend, quadratic functional forms was used due to its higher  $R^2$  value as compared two others forms. The result revealed that the 'C' value in the quadratic functional forms for area, production and productivity were positive and significant for the total food grains in the north eastern India more particularly in state of Assam, Manipur, Meghalaya, Nagaland and Tripura. This implies the acceleration of growth of area, production and productivity of total food grain crops. The growth of area, production and productivity of the total food grains was found to have decreased in the states line Arunachal Pradesh and Mizoram during the period under study.

**Mathur and Henry (2005)** worked on the compound growth rate of area, production and productivity of pulses (Moth bean, Cowpea, and Moong bean) in arid districts of Rajasthan. The compound growth rate (CGR) of Moth bean, Cowpea and Moong bean for different parameters were determined for two periods: long-term (1976-2000) and recent years (1991-2000) for different agro climatic regions of western Rajasthan, India and the Chow's test indicated significant differences in two periods for zone Ib for Moong bean and zones Ib and IIa for Cowpea and there was a positive shift to the technological development during the period.

**Singh and Renu (2009)** worked on the growth of production and productivity of different pulses in Jharkhand. Estimation of compound growth rate and variability were done in the area, production and yield of pea, lentil, chickpea and pigeon pea. The study indicated that there had been a positive change in the area of pulses crops. The variability in the area was observed to be high in pea followed by lentil and pigeon pea and minimum in chickpea. Similarly, variability in yield was also found to be high in pea followed by chickpea, lentil and minimum in pigeon pea.

**Gajbhiye et al. (2010)** conducted a study on growth and instability of chickpea in Vidarbha region of Maharashtra based on secondary data pertaining to the year 1980-81 to 2007-08. The results revealed that the growth rates for area and production of chickpea were found significant. The overall growth rate of area under chickpea was found to be 5.90 per cent which was significant. The growth rate of chickpea production as a whole was significant being 8.72 per cent over the period.

**Rao (2010)** worked on performance of pulses during pre and post-WTO period to study the patterns of growth and magnitude of instability and assessing the explanatory variables effects on pulses production in Andhra Pradesh. The time series data were collected for the period 1986-87 to 2007-08. High growth performance of pulses production was revealed in the result, accompanied by a high degree of instability. Decomposition analysis revealed that area effect was marginally higher than the productivity effect on the production differential. Therefore, growth in production should mainly come from area attributing factors like assured supply of farm inputs and provision of remunerative prices.

**Ardeshna and Shiyani (2011)** explored the growth of area, production and yield of pigeon pea, gram and total pulses in major districts of Gujarat. The data were collected and analyzed for the period from 1960-61 to 2007-08. The acreage under pigeon pea significantly increased in Gujarat at the rate of 1.38 per cent per annum during 1960-61 to 2007-08. Similarly the area under pulses also significantly increased in Gujarat but at a lower rate during 1960-61 to 2007-08. The production of pigeon pea significantly increased at the rate of 5.35 per cent per annum while the production of pulses significantly increased at the rate of 2.95 per cent per annum in the state during 1960-61 to 2007-08. The compound growth rates of productivity of pigeon pea and gram were negative and that of total pulses were positive but non-significant in Gujarat during 1990-91 to 2007-08. The need for development of pulses through technological breakthrough was suggested in the study.

**Mahal *et al.* (2011)** worked on growth and instability in pulses and food grain in Punjab. The study was based on secondary data collected for the period 1960-61 to 2009-10. The results revealed that variability and instability increased in pulses but decreased in food grains. The study had shown that the growth rate of pulse production decreased significantly during this period. It was - 8.09 per cent per annum during sixties and decreased to - 9.16 per cent per annum during 2000-01 to 2009-10. This was due to significant decrease in area *i.e.* - 7.17 per cent for whole period under pulses. The instability in production of pulses was much higher *i.e.* up to 35.47 per cent.

**Bodade and Borker (2011)** attempted to analyze the performance of chickpea production in Buldana district of Vidarbha region was based on the secondary data pertaining to the year 1990-91 to 2008-09 to evaluate the growth and instability of

chickpea. The growth rate for area of chickpea was found to be significant as per the result was found significant. High instability was witnessed in the production of chickpea in the study conducted in Buldana.

**Acharya *et al.* (2012)** worked on growth in area, production and productivity of major crops in Karnataka, India using compound growth rate for estimating the growth trends. The secondary data for a period of 26 years from 1982-83 to 2007-08 were collected. Significant positive growth was seen in growth rate in area under pulses, vegetables, spices and fruits and nuts while cereals showed significant negative growth. The growth in area under oilseeds and commercial crops was negative and insignificant. Similarly the production of cereals, pulses, vegetables and fruits showed a significant positive growth. The production of oilseeds and commercial crops registered insignificant positive growth. Significant growth was recorded in the productivity as cereals, pulses and fruits. Moderately positive growth was recorded in the productivity of oilseeds.

**Sharma *et al.* (2013)** worked on growth and trends of pulse production in India. On data pertaining to the period 1980-81 to 2008-09 and divided into two parts *viz.*, before (1980-81 to 1994-95) and after (1995-96 to 2008-09) launch of TMOP. The positive per cent change in area, production and yield of pigeon pea, chickpea and total pulses had been observed during both before and after launch of technology mission on pulses (TMOP) except in case of lentil. In case of, area of chickpea and yield of pigeon pea also showed negative per cent change before launch of TMOP. Area of pulses had been almost stable with few exceptions as compared to production and yield of pulses. Instability in export and import had been quite high during the period of study.

**Shende *et al.* (2013)** undertook the study on growth rate and instability of area, production and productivity of three major crops *viz.*, jowar, cotton and soybean based on secondary data for the period of 23 years (1984-85 to 2006-07) for the districts *viz.*, Buldana, Yavatmal, Akola, Amravati and Amravati division as a whole of Western Vidarbha of Maharashtra. The study revealed that in overall period the compound growth rate for almost all the districts in Amravati division declined by 3 per cent per annum in area as well as production for the Jowar crop. The growth rate of cotton in almost all districts of Amravati division and also division as a whole was found to decline drastically in period-II as compared to period-I, except Akola district.

The growth rates were also worked out and found to be positive and significant in all districts of Amravati division in area, production and productivity of soybean.

**Chowdhury *et al.* (2014)** worked on oilseeds area and production variability in Bangladesh to measure the change and instability of oilseeds in area, production, and yields on data collected for the period from 1987 to 2010. The results of study revealed that the production and yield of oilseeds increased sharply though the cultivable areas decreased. The growth rate in production and yield of oilseeds were satisfactory although unstable over the study period. Moreover, the results showed that it was insufficient to fulfill the present demand of vegetable oil in Bangladesh.

**Devraj *et al.* (2014)** examined the growth and instability of chickpea production in Maharashtra state on collected data pertaining to the period 1980-81 to 2009-10 and divided into three parts *viz.* (1980-81 to 1989-90, 1990-91 to 1999-2000 and 2000-01 to 2009-10). The exponential function  $Y = b^t$  and coefficient of variance were used to measure the growth and instability in area, production and productivity of chickpea. During the overall period, the growth performance of chickpea in Maharashtra state as a whole showed significant positive growth rate in area (2.33%), production (3.45%) and productivity (2.60%). The highest compound growth rate of chickpea acreage was observed in Yevatmal (7.64%) district. In case of productivity, growth rate was found to be the highest in Aurangabad (3.78%) district of the state. During the overall period of study, the state as a whole recorded instability in area, production and productivity which was to the tune of 37.47, 60.30 and 27.33 per cent, respectively.

**Inbasekar (2014)** analyzed the challenges and strategies to increase pulses production with special emphasis on chickpea and pigeon pea in India based on secondary data from 1960-2010 collected from authentic published sources. Compound growth rate was estimated to study the yield performance in the major states revealing in the study that there was low yield growth in chick pea and pigeon pea in the majority of the states. Totally 3.2 million tones and of additional pulses can be produced by extending pulses area to rainfed rice fallow lands, replacing low productive crops and summer fallows.

**Pichad *et al.* (2014)** recorded the production performance of chickpea in Amravati district of Maharashtra that was carried out with the objectives on growth

rates and variability in area, production, and productivity of chickpea. The secondary data on area, production and productivity of chickpea in Amravati district were collected from various issues of periodical Epitome of Agriculture and district socio-economic reviews. So the data pertained to the period of 20 years in two periods i.e. Period I (1990 - 1991 to 2000 - 01) and Period II (2001- 2002 to 2009 - 10). Compound growth rates for area, production and productivity for period II were found positive and significant as revealed from the result.

**Sihmar (2014)** worked on growth and instability in agricultural production in Haryana on secondary data collected from 1980-81 to 2006-07 and divided into three periods (1980-81 to 1989-90, 1990-91 to 1999-2000 and 2000-01 to 2006-07). The results showed that, total pulse production had declining trend over the period. Being highest in gram in both, production and area. Moong registered negative growth rate during 1980's and 1990's while it showed positive growth rate during 2006-07. The trends of instability were high in many crops like gram, moong and masoor in all the periods because areas under these crops were shifted towards rice and wheat.

**Boyal *et al.* (2015)** carried out the study to find out the compound growth rates and instability of seed spices crop in selected districts of Rajasthan and for the state as a whole for the period I (1991-92 to 2000- 01), period II (2001-02 to 2010-11) and overall period (1991-92 to 2010-11). Results of study revealed that the production of coriander crop increased significantly in Kota (6.18per cent), Jhalawar (9.65%), Baran (11.10%) districts and state as a whole (9.10%) and production of cumin spice decreased in Jalore district (-7.66%), Jodhpur district (-7.78%) and state as a whole (-1.03%) during period I which was due to negative growth in productivity under the crop by-2.16, -12.68 and-3.19 per cent per annum. Similarly, production of fenugreek crop increased significantly in Kota (64.50%) and Jhunjhunu (36.22%) districts. The magnitude of instability in cumin crop was higher in production as compared to productivity and area except Barmer district during period I, where the variation in productivity was more.

**Savitha and Kunnal (2015)** worked on growth performance of cereals in Karnataka to examine the trend in growth rates of major cereals *viz.*, maize, paddy, sorghum and wheat by using the compound growth rate function. The necessary secondary data were collected from major 5 districts for each crop based on the highest area for a period of 15 years from 1998-99 to 2012-13. The growth of area of

total cereals showed a substantial annual decrement. Further, the production and productivity of the total cereals recorded a positive annual increment. The area under paddy, maize and wheat had recorded a mild annual increment whereas jowar registered a significant negative growth in the state as a whole.

**More et al. (2015)** conducted a study to compare the performance of pulse crops in Gujarat state in high growth period and across the earlier periods. Performance of crop was analyzed decade wise *i.e.* period-I to period-V and results showed that, pulse area in the state was considerably increased. In recent years, area under pigeonpea (*Cajanus cajan*) and other pulses was decreased and chickpea area was increased. Pigeonpea and other pulse crops *i.e.* green gram (*Vigna radiata*) and black gram (*Vigna mungo*) had recorded phenomenal growth during the year 1970-1980. Chickpea (*Cicer arietinum*) crop performed better during high growth period of Gujarat, compared to other pulse crops. Period – III *i.e.* 1981 to 1990 was recorded as anti-pulse decade in which productivity of all the major pulses was obstructed. Pigeonpea crop was more stable compared to other pulse crops in the state. Area expansion was a major reason for increase in production of pigeon pea and chickpea in the state. The production of green gram and black gram was increased because of improvement in the yield and its interaction with area.

**Sharma (2015)** conducted a study on trends of area, production and productivity of spices in the northeastern region. The study was based on secondary data from 1982-83 to 2011-12. The data was collected from several government publications and web series. To analyze the trend of area, production, and productivity of major spices of NE region, the linear, quadratic and exponential functional forms were used. To fit the trend, exponential functional forms was used due to its higher  $R^2$  value as compared to other two forms. The result revealed that the value of a and b in the exponential function forms for area, production and productivity were positive and significant for major spices. This indicated that the acceleration in growth of area, production and productivity of major spices. Besides these, compound growth rate, coefficient of variation was also estimated. The growth of area, production and productivity of major spices were found to decrease in region during the period of 2002-03 to 2011-12.

**Uddin et al. (2015)** measured the change and instability in area, production and yield of pulses in Bangladesh based on secondary data during the period 1986 to

2009 collected from Bangladesh Bureau of Statistics in the study. The analysis revealed that the area and production of pulse showed no satisfactory increase. Though the yield of pulse had increased, it is insufficient to meet the demand of the country. The analysis also revealed instable area, production and yield of pulses during the study period.

**Patil and Yeledhalli (2016)** worked on growth and instability in area, production and productivity of different crops in Bengaluru division. This study was based on secondary data for a period of 10 years from 1998-99 to 2013-14. The results revealed that Bengaluru urban had the highest CAGR which was 24.26 per cent in productivity in avare was significant at 5 per cent level. In Bengaluru Rural the highest CAGR was 22.26 per cent in productivity of avare (significant at 1%). Production of chrysanthemum had growth of 22.36 per cent was the highest annual growth and 4 per cent (area of tamarind) was found to be lowest instability for selected crops in Chitradurga. In Davanagere the highest CAGR was observed in productivity of tomato (9.12%). In Kolar district, 19.65 per cent instability observed in production of avare and was significant at 1 per cent. In Shivamogga district highest CAGR observed in production of sunflower to an extent of 29.57 per cent. In Tumkuru area under green chillies was growing at the rate of 34.46 per cent per annum. It was observed that the growth in area, production and productivity of pulses have been increased significantly.

**Kumar and Devraj (2016)** carried out the survey to discuss the growth in area, production and productivity of agricultural commodities in Karnataka. The study was based on secondary data collected for a period of 14 years from 2000-01 to 2013-14. Growth rates estimated for changes in area under different crops showed a significant positive growth in area of pulses, commercial crops, while cereals and oilseeds showed significant negative growth in area under major cereals and oilseeds like Jowar, Ragi, Bajra and Minor Millets in cereals and Groundnut, Sunflower, Castor in oilseeds are experiencing a substantial annual decrement. Similarly the production of cereals, pulses, commercial crops showed a significant positive growth rate. The production of oilseeds registered insignificant and negative growth. The productivity of pulses, commercial crops, registered significant growth. Productivity of cereals and oilseeds recorded negative and insignificant growth.

**Suman et al. (2018)** assessed agriculture production growth and instability in Rajasthan using the secondary data for 20 years (1995-96 to 2014-15). Results revealed that bajra recorded the highest growth in production and productivity *i.e.* 6.43 per cent and 6.07 per cent and barley observed the highest growth in area by 2.83 per cent in cereals. The lowest growth was recorded by paddy in area, production and productivity. The moong pulse crop recorded highest growth rates in area, production and productivity. Arhar recorded lowest growth rates in area and production while gram recorded the lowest growth in productivity. In case of instability pulses moth, urd, moong and arhar were found to have very instable yield with very high coefficient of variation values.

**Boyal and Mehra (2016)** made an attempt to know the growth and export performance of major seed spices in Rajasthan and export performance of these major seed spices from India. The data of major seed spices in Rajasthan for 23 years from the year 1991-92 to 2013-14 of coriander, cumin, and fenugreek and export data of same in India for 20 years from the year 1995-96 to 2014-15 were selected for the analysis. It was revealed in the results that the growth in area and production of major seed spices in Rajasthan was found to be positive, while growth in productivity of cumin in Jodhpur and Rajasthan were found to be negative as well as fenugreek productivity in sikar district was also found negative. The exports growth of selected seed spices in terms of quantity and value were found to be increasing.

**Chandra (2017)** explored trends in area production and productivity of groundnut in Uttar Pradesh by using secondary data of groundnut area, production and productivity collected from statistics published by Ministry of Agriculture and Farmers Welfare. A fifty years (1964-65 to 2013-14) time series data has been used to apply orthogonal polynomial technique to get trends in area production and productivity. By using simple regression analysis relative strength of area and productivity effect had been calculated. India had been ranking among top three producers of groundnut in the world, Gujarat, Tamil Nadu and Madhya Pradesh being the major producing states in the country. However, there had been a consistent fluctuation in the area and production over the years and across the states. Uttar Pradesh being one of the most populous state in the country had been ranking amongst the top two states as far as mustard production is concerned. However it ranked 8<sup>th</sup> as far as the production and productivity of groundnut was concerned.

**Dash et al. (2017)** analysed growth and instability in pulses production of Odisha during rabi season. The economic reforms in the 1991-92, affected the agriculture scenario of Odisha following the study period (1970-71 to 2013-14) that had been divided into pre-reform (1970-71 to 1991-92) and post reform (1992-93 to 2013-14) period. The study of the growth rate of area and production was estimated by using the compound growth function. Agriculture in Odisha during rabi season was based mainly on pulse crops. The study of the growth rate of area, production and yield of rabi pulses in the two periods the pre-reform to post –reform period was found to be highly significant but negative in case of area and production, whereas, in case of yield it was negative as well as non-significant.

**Latika et al. (2017)** analyzed the trend in production of total pulses for the period 1950-51 to 2014-15, i.e. past six and half decades in India. The study of the growth rate of area and production was estimated by using the compound growth function. The gross area under total pulses in India was in the range of 19-25 million hectare per year over these six decades. The average production of total pulses was in the range of 8 million tones to 15 million tones per annum over the 6 decades. However, the yield of total pulses had increased over the years. The yield of total pulses was 400 kg/ha during 1950's which had increased to above 700 kg/ha during 2014-15. The compound growth rate of yield over six decades was positive and significant while area and production were found non-significant.

**Ahmad et al. (2018)** examined the growth and instability in pulses in eastern India during the period from 2013 to 2016 by using the compound growth function revealing in the study that the share of area and production of pulses in total food grains production had risen. The area under total pulses in TE-2003 was worked out to be 7.52 per cent of the total area under food grains in the region, which became almost double, i.e. 14.48 per cent in TE-2016. Production of pulses had increase from 2.99 per cent in TE-2003 to 6.22 per cent in TE- 2016 and productivity had also improved (635.01 to 910.68 Kg/ha) during study period. The compound growth rates of area and production were found positive in all the states. Though there was a wide gap between consumption and production, on account of low productivity of pulses, they were not able to compete with profitability as gained by cereal crops, thus resulting in decreased area.

**Avinash and Patil (2018)** explored the trends in area, production and productivity of major pulses in Karnataka and India. Results showed that the cultivated area was fluctuating from year to year due to number of biotic and abiotic stresses, which were responsible to a large extent for the low yields. The growth rate in area, production and productivity of selected pulse crops were computed for a period of 36 years from 1980 to 2016 (period-I from 1980 to 1990 and period-II from 1991 to 2016) by using the compound growth function. Pertaining to total pulses scenario in Karnataka study revealed that the growth in area, production and productivity was found positive in all the periods except productivity (-0.82%) in period-I. It was important to highlight that though the growth rates of productivity was found negative, the production was found positive in period-I. Statistics of the country as a whole showed positive growth in area, production and productivity in both the periods. However, it is worth noting that the production and productivity was found positive and significant in all the periods.

**Bisht and Kumar (2018)** studied trends in area, production and yield of major pulses in India through growth rate analysis for the last 20 years from 1996-97 to 2015-16. This period was further divided into two sub periods: Sub period I (1996-97 to 2006-07) and Sub period II (2007-08 to 2016-17). The growth rates were calculated by fitting the exponential growth function. The results had shown a highly significant but low growth rate of 2.14 per cent in pulses production during this period. This growth rate was significantly higher in the sub period II. The area and yield under pulses had also shown a marginal but significant growth rate of 0.44 and 1.19 per cent, respectively. However yield growth rate was found to be higher than the growth rate in area which showed that area allocation under pulses was increasing slowly even after imposition by National Food Security Mission(NFSM) through improvements in yield.

**Changela and Devi (2018)** explored the trend in area, production and productivity of major pulse crops i.e. chick pea and pigeon pea growers in Gujarat as well as India. The study based on the secondary data from 2001-02 to 2016-17 by using log linear model. The results showed that compound annual growth rates of area, production and productivity were positive and significant for total pulses in India while in Gujarat production and productivity increase were increased significantly. Further it was observed that the CGAR of area, production and

productivity of chick pea was positive and significant, whereas in case of pigeon pea the CGAR of production and yield was positive and significant in Gujarat.

**Bairwa et al. (2020)** conducted a study on inter temporal production performance of pulse crops: in Indian context. The study was based on secondary data. The study divided in three period viz. Period-I (1998-99 to 2007-08), period-II (2008-09 to 2017-18) and period-III (1998-99 to 2017-18). The semi log modal was used to analyze the compound annual growth rate. During period-I, the CAGR clearly found that area and production of gram reported the highest growth rate of 1.84 and 1.76 per cent, respectively. In case of productivity, the highest growth rate reported in black gram at the rate of 0.26 per cent during the same period. During second period, the highest CAGR in area, production and yield was found in black gram with the magnitude of 6.00, 10.30 and 4.10 per cent respectively. During period-III, improved growth rate in area and production is examined at the rate of 2.50 and 3.90 per cent in chickpea. The highest growth rate for yield is reported in black gram at the rate of 2.20 per cent.

**Sangeetha et al. (2020)** explored the scenario of major pulse production in Tamil Nadu: A growth and decomposition approach. The study was based on secondary data from 1965-66 to 2016-17 i.e. past six decade in Tamil Nadu state. The compound annual growth rate was calculated by using the log linear model. The CAGR of productivity over six decades was positive and significant. In area and production except the period-II were negative signs. Area under black gram, green gram, red gram, Bengal gram and total pulses were registered positive growth rate during 1965-66 to 1985-86.

From the foregoing review, it can be concluded that growth rate of area, production and productivity were observed by various authors. The results from various studies reviewed showed that growth in area and production were increased per annum but growth in productivity was very low. To analyze the trend of area, production and productivity, the linear, quadratic and exponential functional forms were used. To fit the trend, quadratic functional forms was used due to its higher  $R^2$  value as compared to others forms. The result revealed that the 'C' value in the quadratic functional forms for area, production and productivity were positive and significant. This implies the acceleration of growth of area, production and

productivity of pulse crops. The growth of area, production and productivity was found to have decreased.

## **2.2 Acreage and yield response in growth of pulse crops**

**Kumar *et al.* (2009)** studied trade and decomposition analysis of lentil in India for the period 1970 -71 to 2006- 07. The total time period was classified into three and half decades, namely 1970-71 to 1979-80, 1980-81 to 1989-90, 1990-91 to 1999-2000 and 2000-2001 to 2006-07. The lentil production in India had increased from 374.6 to 910 thousand tonnes during 1970-71 to 2006-07 as a result of area expansion for the crop. During the overall period, the change in total production of lentil was completely due to change in area under the crop as yield and interaction effects were very small.

**Shende *et al.* (2011)** attempted to study the decomposition and acreage response of soybean in western Vidarbha based on time series secondary data on the rainfall, farm harvest price and other data, which were obtained from various Government publications. Nerlovian lagged adjustment model (1958) was used in supply response analysis based on time series data. The study revealed that during overall period, the area effect (46.98%) was the most responsible factor for increasing soybean production in Amravati division with positive yield and interaction effect *i.e.*, 1.91 per cent and 51.41 per cent, respectively. While Coefficient of variation and instability for area, production and productivity were high, indicating that soybean appeared to be one of the important emerging crop in the western Vidarbha zone and it become additional crop in the cropping pattern of the region.

**More *et al.* (2015)** conducted a study on production performance and decomposition analysis of pulses crops in Gujarat state to compare the performance of pulse crops at state level in high growth period and across the earlier periods. Time series data for a period of fifty one years from the year 1960-61 to 2010-11(Period-I 1961 to 1970, Period-II 1971 to 1980, Period-III 1981 to 1990, Period-IV 1991 to 2000 and Period-V 2001 to 2010) were used. Performances of crops were analyzed decade wise *i.e.* period-I to period-V and overall period with the help of statistical techniques like average, growth rate and decomposition model. Results showed that, pulse area in the state had considerably increased. In recent years, area under pigeonpea and other pulses decreased whereas chickpea increased. Pigeon pea and

other pulse crops i.e. green gram and black gram have recorded phenomenal growth during the year 1970-1980. Chickpea crop performed better during high growth period of Gujarat, compared to other pulse crops. Period– III i.e. 1981 to 1990 was recorded as anti-pulse decade in which productivity of all the major pulses was hampered. Pigeon pea crop was more stable compared to other pulse crops in the state. Area expansion was a major reason for increase in production of pigeon pea and chickpea in the state. The production of green gram and black gram had increased due to improvement in the yield and its interaction with area.

**Sandeep *et al.* (2016)** conducted a study on the decomposition and acreage response of pigeonpea in western Vidarbha. The study was based on secondary data collected from western Vidarbha. The data pertained to the period 1983-84 to 2012-13 and the period was observed as breakup of 10 years as: (a) Period I –1983-84 to 1992-93, (b) Period II –1993-94 to 2002-03, (c) Period III –2003-04 to 2012-13 and (c) Overall IV –1983-84 to 2012-13. Nerlovian lagged adjustment model (1958) was used in acreage response analysis based on time series data. The study revealed that the compound growth rate for area and production under pigeonpea was recorded high during period I in all the districts. During period II, the area, production and productivity of pigeonpea registered mostly negative growth rates in all the districts. During period III, the compound growth rate for area, production and productivity under pigeonpea had increased in all the districts of western Vidarbha region. For the overall period, in pigeonpea, the area effect (56.61%) was most responsible factor for increasing production in Amravati division with positive yield and interaction effect i.e. 18.91 per cent and 23.75 per cent respectively.

**Latika *et al.* (2017)** attempted to analyze the trend in production of total pulses in India for the period 1950-51 to 2014-15, i.e. past six and half decades in India. The gross area under total pulses was in the range of 19-25 million hectare per year and average production of total pulses was in the range of 8 million tonnes to 15 million tonnes per annum over the 6 decades. The decomposition analysis showed that increase in production of pulses during the period 1995-2014 was mainly due to yield effect. Since the supply of resources especially land was limited in nature, productivity of pulses should be boosted up by adoption of improved technologies like hybrid pulses cultivation and various techniques of production to meet the future increased demand.

**Changela and Devi (2018)** explored the trend in area, production and productivity of major pulse crops i.e. chick pea and pigeon pea growers in Gujarat as well as India. The study based on the secondary data from 2001-02 to 2016-17 by using decomposition analysis model. The results showed decomposition analysis was concluded that increasing in area of chickpea, pigeon pea and total pulses play an important role in increasing production of these crops in India but in Gujarat increase in yield was responsible to increase total production of pulses.

**Bairwa et al. (2020)** conducted a study on inter temporal production performance of pulse crops: in Indian context. The study was based on secondary data. The study divided in three period viz. Period-I (1998-99 to 2007-08), period-II (2008-09 to 2017-18) and period-III (1998-99 to 2017-18). The decomposition analysis model was used to analyze the relative contribution of area, yield and interaction component. The decomposition analysis of production revealed that the area effect and yield effect was the major source to produce the production growth in kharif and rabi pulse crops, respectively

**Sangeetha et al. (2020)** explored the scenario of major pulse production in Tamil Nadu: A growth and decomposition approach. The study was based on secondary data from 1965-66 to 2016-17 i.e. past six decade in Tamil Nadu state. The results revealed that the increase in production of black gram, green gram, Bengal gram and total pulses were contributed by their yields, whereas area and its interaction with yield have adversely affected the production. Decline in production of horse gram was due to area effect and interaction effect. The decomposition analysis shows that increase in production of pulses during the period 2006-2016 was driven by yield improvements. Since the supply of resources, especially land is limited in nature, productivity of pulses should be boosted up by the adoption of improved technologies like hybrid pulses cultivation and various techniques of production to meet the future increased demand.

It was revealed from above the reviews that the decomposition analysis of production was revealed that the area effect and yield effect was the major source to produce the production growth in kharif and rabi pulse crops, respectively. Area expansion was a major reason for increase in production of pigeon pea and chickpea in the selected state. The production of green gram and black gram had increased due to improvement in the yield and its interaction with area.

### 2.3 Instability in area, production and productivity of pulse crops

**Sundaravaradarajan *et al.* (2001)** indicated that the quantity of kernels exported and production of raw cashew showed desirable instability and instability in import of raw cashew was undesirable. They further suggested that even if India doubles the production of cashew, there would not be any marketing problem or price fall. In order to increase the domestic production of raw cashew nuts through developing high yielding varieties and infrastructures for post-harvest operations, warehousing *etc.* and diversifying the market for cashew kernels suitable action should be taken by strengthening the non-traditional markets.

**Purbia (2002)** studied the trend, growth and instability in production of major crops in Rajasthan using secondary data for the year 1970 to 2000 and techniques like compound growth, linear trend equation and instability indices.

$$\text{Instability index (I}_1\text{)} = \frac{SD}{AM} \times 100$$

SD = standard deviation of area/production/productivity of crops for a specified period.

AM = Arithmetic mean of area/production/productivity of crops.

$$\text{Instability index (I}_2\text{)} = \frac{SD^*}{AM^*} \times 100$$

SD\* = standard deviation of detrended area/production/productivity of crops.

AM\* = Arithmetic mean of area/production/productivity of crops in a specified period.

$$\text{Instability index (I}_3\text{)} = CV \sqrt{1 - R^2}$$

CV = Coefficient of variation of area/production/productivity of the crop.

R<sup>2</sup> = Coefficient of determination of the trend equation for original time series data on area/production/productivity.

On analyzing it was found that the growth rate of area of wheat, rapeseed mustard, maize, groundnut, rice, dry chillies, coriander and guar were positive and maize was found to be highly stable crop in area while wheat emerged highly stable crop in both production and productivity. It was concluded that production strategy

for the crop must aim to enhance the production and productivity growth without causing much inter year instability. During seventies (1970 to 1980) wheat emerged as highly stable crop and sesame as highly unstable crop in productivity. In eighties (1980 to 1990), kharif pulses showed the highest instability, while rapeseed and mustard had the lowest instability in productivity in context of  $I_2$  and  $I_3$  instability measures. Guar was found as highly unstable crop and barley as highly stable crop in productivity during nineties (1990 to 2000). Instability analysis of the period of 1970 to 2000 revealed that the sesame emerged with the highest instability in productivity.

**Wasim (2003)** explained in the acreage allocation behavior of maize cultivators in North-West Frontier Province (NWFP), Pakistan, in terms of their responsiveness to price and non-price factors over the period of 1970-71 to 1998-99 on the study based on secondary data. The estimation procedure relied on an improvised Nerlove's partial adjustment lagged model. The result of the analysis revealed that in the process of making the area decisions for maize cultivation all the variables (relative profitability, irrigation, prices and yield risk, rainfall, plant protection measures and lagged maize acreage) were equally important.

**Kumawat and Meena (2005)** studied instability in area, production and productivity of coriander crop in Rajasthan state and major producing districts. Study was conducted for the period I (1972-73 to 1985-86), period II (1986-87 to 1999-2000) and overall period (1972-73 to 1999-2000). The coefficients of variation for area under coriander crop in the state were 17.11, 13.66 and 38.63 per cent for period I, II and overall period, respectively. The coefficients of variation for production of coriander seed in the state of Rajasthan were 46.73, 28.89 and 75.14 per cent during the period I, period II and overall period, respectively. The variation in area was the highest in Kota district (53.81 per cent) and lowest in Bundi district (23.17 per cent) in period I, while in period II it was highest in Jhalawar district (23.76 per cent) and lowest in Kota district (16.59 per cent). For the overall period highest variation in area was observed in Bundi district (59.92 per cent) and lowest in Baran district (22.51 per cent).

**Mahir and Abdelaziz (2005)** conducted study to measure the extent of instability and analysed the sources of changes in mean production of the main crops grown in New Halfa Agricultural Corporation, Sudan before and after the adoption of liberalization policy. They found standard deviation (SD) of sorghum production was

67.09 per cent in period I (1970-71 to 1991-92) and became 88.37 per cent in period II (1992-93 to 2007-08). Wheat production fluctuation was 43.41 per cent and 61.44 per cent during the first and the second period, respectively. Lowest production fluctuation was found in cotton during period II (27.62 per cent) and fluctuations of groundnuts production was also found low (39.30 per cent) in the same period.

**Jhagrawat (2006)** assessed the agricultural production growth and instability during the new economic regime in Rajasthan for the period of 1990-91 to 2004-05. She observed that coefficient of variation (CV) in cereals i.e. bajra and jowar emerged with high CV values for yield and in the pulses, moth, moong and arhar were found to have very high CV values. In oilseeds CV values of yield ranged between 16.4 per cent for rapeseed & mustard to 57.79 per cent for sesamum. In spices, the CV values for the yield varied between 8.97 per cent for garlic to 37.74 per cent for turmeric. All the fruit crops were found to have high CV values for the yield ranging from 34.35 per cent for guava to 68.07 per cent for sapota.

**Tingre et al. (2006)** examine the acreage response to various factors determining the decisions regarding the allocation of land to wheat and rabi jowar in Vidarbha Using Nerlovian lagged adjustment model (1958) for the acreage response analysis. Results revealed that lagged area under wheat and rabi jowar influenced positively the current acreage under these crops. Yield risk variable in production of wheat influenced the current acreage under this crop, whereas it was negatively influenced in case of rabi jowar. Lagged price of competing crop influenced the current acreage under wheat and rabi jowar negatively. In wheat lagged yield of competing crop i.e. gram affected the current acreage under wheat negatively. In acreage response study, the farmers showed rapid adjustment for acreages under wheat whereas they were slowly responsive towards adjustment of their acreages under rabi jowar in Vidarbha.

**Tuteja (2006)** worked on growth performance and acreage response of pulse crop at state level in India and revealed that empirical results on the extent of responsiveness of price and non-price factors to acreage of gram, arhar, moong, urad, masoor and total pulses in India and major growing states varied widely in different milieu. The results showed that acreage allocation in rabi pulses, i.e. gram and masoor got influenced by lagged acreage followed by relative price in most of the analyzed cases whereas in kharif pulses i.e. in allocating land to arhar, moong and urad, farmers

considered lagged acreage and magnitude of pre-sowing rainfall as the most important factors.

**Anug *et al.* (2007)** studied the impact of market reform by examining acreage response of pulses to price under agricultural market reform in Myanmar with Nerlove partial-adjustment model covering yearly data from 1988-2004. Acreage response to liberalization of prices and marketing was found statistically significant. In export crops like black gram, green gram, pigeon pea and chickpea except soybean acreage response liberalization of prices and marketing was significant statistically with lack of export demand. Although the short-run elasticity of acreage was less than unity, the long-run elasticity was quite greater than unity. Agricultural market reform, with price incentive to farmers, can induce the motivation of production. However, complementary interventions for the improvement of infrastructure, marketing, access to inputs and credits, production technology etc. were found prerequisite.

**Chand and Raju (2008)** studied instability in production of rice, groundnut and cotton in Andhra Pradesh for the period of 1979-80 to 2003-04, which was divided into two sub-periods, viz. 1979-80 to 1992-93 and 1993-94 to 2003-04. Instability in area, production and yield of rice, cotton and groundnut experienced at the state level during 12 years before and after 1992-93. Instability for area has shown an increase after 1992-93 for rice and cotton and decline in the case of groundnut. It increased from 11.5 to 13.4 per cent in rice and from 17.5 to 18.8 per cent in cotton. During both the periods, instability in area was the lowest in groundnut. Rice, which is generally grown under irrigated conditions, showed somewhat higher instability in area as compared to groundnut. Area under cotton has shown more than double the fluctuations in area under groundnut.

**Mohanakumar (2008)** conducted a study on sources of instability in natural rubber price: an analysis in the post-reform phase and analyzed the stability/instability and the sources of instability in natural rubber price during pre and post-liberalization periods. As a result, demand side variable too contributed significantly to natural rubber price instability in the post-liberalization period. The contribution to natural rubber price instability from supply side factor still remained robust resulting to a cumulative effect on price instability in the domestic market during the post-liberalization phase.

**Gajja et al. (2008)** conducted a study to analyze the growth and instability in area, production and productivity of sesame and its acreage response in the arid zone of Rajasthan, study being confined to six districts having more than 10000 hectare under sesame cultivation during the last decade. Data were collected from 1960 to 2003 period and analyzed using exponential production function. The allocation of area to sesame crop guided by rainfall during crop growing season, yield lagged by one year; and in Bikaner and Jodhpur districts only had positive response to lagged price.

**Gajja et al. (2009)** analyzed the growth and instability in area, production and productivity of chili and acreage response to chili crop in the arid zone of Rajasthan. The study was confined to five districts of the arid zone having more than 500 hectare area under chili cultivation during the last decade. The data were collected for the period 1960-2007 and analyzed by using exponential production function and instability index. The area and production had increased in the arid zone of Rajasthan but with high instability. The productivity registered lower but relatively more stable growth compared to the area and production which indicated that chili production could be increased by stabilizing and sustained increase in the area under chilli cultivation by efficient use of irrigation water. The farmers of the arid zone of Rajasthan would tend to divert more area towards cash crop if current irrigation facilities were adequate.

**Kumaravardan et al. (2009)** examined the performance of 15 major crops in Tamil Nadu since liberalization in their study by using time series data for the period 1980-2005. The study on acreage response of crops to various price and non-price factors was influenced by lagged price and the price of competing crops showed the extent of area allocated for a crop. Short-run and long-run elasticity's of acreage showed that farmers cultivating commercial crops and adjust their cropping pattern very quickly in response to price.

**Awaghad et al. (2010)** conducted the study on growth and instability of cotton in Western Vidarbha Region of Maharashtra for the period I (1990-91 to 1999-2000), period II (2000-01 to 2008-09) and overall period (1990-91 to 2008-2009). The study was conducted for the area of Amravati, Buldhana and Akola district. The extent of instability in cotton production in the Western Vidarbha region decreased by 33.27 per cent, 34.94 per cent and 35.90 per cent in the period I, II and overall period,

respectively. This instability of cotton in the region was the effect of instability experienced by cotton technology in the farming system. This happened due to advancement in research pertaining to evolution of high yielding variety of cotton over the period of time and adoption of improved technology by the cotton grower in the region.

**Gajbhiye *et al.* (2010)** evaluated the instability of chickpea production in Vidarbha region of Maharashtra based on secondary data pertaining to the years from 1980-81 to 2007-08 using Cuddy- Della Valle Index. Instability in chickpea indicated that productivity under chickpea exhibited less variation meaning that production of chickpea over the period had been almost constant.

**Kachroo *et al.* (2010)** studied growth and instability of major oilseeds of India based on logistic and Coppock's model. As per Coppock's instability indices, except for sunflower where tremendous variation in area were found to be i.e. 371.47 per cent, 241.11 per cent, 87.43 per cent, 150.99 per cent and 125.06 per cent for north zone, east zone, west zone, south zone and all India level, respectively and production instability was found to be 71.64 per cent, 97.28 per cent, 67.50 per cent, 36.96 per cent and 51.85 per cent for north zone, east zone, west zone, south zone and all India level, respectively, otherwise all the variables (area, production and yield) of different oilseed varieties under present study showed a moderate variation ranging in between 10 per cent to 20 per cent.

**Khan and Khair (2010)** conducted a study on production and acreage response of wheat in the North West Frontier Province (NWFP). The influence of market price (price factor) and rainfall (non price factor) on wheat production and acreage by employing Nerlovian adjustment model in time series data over a period of time (1981-82 to 2007-08) in NWFP was determined. The findings were obtained by applying ordinary least squares (OLS) technique of estimation, which revealed that positive and significant relationship ( $P < 0.05$ ) was observed between wheat production and rainfall. In case of wheat production, short and long run elasticity's of market price was worked out to be 0.014 and 0.027 and of rainfall 0.130 and 0.256, respectively. While in case of wheat acreage, the short and long run elasticity's of market price were estimated as -0.016 and -0.078 and of rainfall as 0.032 and 0.150, respectively. The larger value and positive sign of F-ratio revealed highly significant overall research finding ( $P < 0.01$ ). It revealed that merely market price announcement

was not enough, but the adequate and timely supply of water mainly through rainfall had been proved vital input in achieving wheat production targets over a period of 27 years (1981-82 to 2007-08) in NWFP. The Government was required to their emphasis from market price announcement to the irrigation practices for wheat production enhancement.

**Pal (2010)** examined the growth and instability in production and export of Indian lac for 38 years spanning from 1970-71 to 2007-08 analyzing the data using exponential function and instability index. During the overall period production of Indian lac registered a declining trend while, in the period 2000-01 to 2007-08 was comparatively better with positive growth rate and lower instability than the past three decades of lac production in India. Instability was more in total export value and unit value of export in comparison to export quantity. Instability during the period 2000-01 to 2007-08 was comparatively lower than the past three decades and overall period in quantity, total value and unit value of export. The study emphasized on the need of intensification of efforts and exploitation of untapped potential area for increasing lac production, quality consciousness and more R & D support for improving the production and export scenario of Indian lac.

**Bera *et al.* (2011)** studied growth and instability in food grains production both at the country as well as state level (West Bengal) for the period ranging from 1950 to 2006 and also to find out the impact of modern crop production practices designated as green revolution technology occurred during mid-sixties. The study revealed that India attained instability measured in area, production and productivity of 2.91, 0.36 and 0.05 per cent per annum, respectively. The state West Bengal witnessed acceleration at the rate of 29.29, 224.08 and 29.37 per cent in area production productivity, respectively associated with the variability of 3.14, 01.47 and 1.90 per cent, respectively in the same order.

**Bodade and Borkar (2011)** conducted a study on the production performance of chickpea in Buldana district of Maharashtra chosen purposively on the basis of the highest area and production. The study was based on the secondary data that pertained to the year from 1990-91 to 2008 09. Instability was calculated by using Cuddy- Della Valle Index. The instability studied in Buldana indicated that production of chickpea had witnessed high instability.

**Sakamma and Ananth (2011)** studied growth and instability in production and export of major spices in India for the period 1985-86 to 2006-2007 and this period was divided into two sub-periods *viz.* period I from 1985-86 to 1996-97 (pre-WTO) and period II from 1997-98 to 2006-07 (post-WTO). For the present study five major spices of India namely chilli, pepper, cumin, turmeric and coriander were chosen purposively because these five spices, accounted for 77.9 per cent of area and 64 per cent of production of total spices. Instability was high in terms of export value than the export quantity and these instability values were high in pre-WTO period compared to post-WTO period for the spices chilli, turmeric, and coriander. However, in case of pepper and cumin a reverse trend was found.

**Aruna and Upender (2012)** carried out the study to generate empirical information on the price elasticities of acreage under groundnut crop in the state of Andhra Pradesh, India fitted acreage response function to the time series data collected for the period from 1968 to 2002. The empirical results showed the responsiveness of the acreage under groundnut crop to increase in lagged prices was relatively inelastic in short run and after some time it was more elastic in Andhra Pradesh.

**Ashoka *et al.* (2013)** studied growth, instability and direction of chili trade in India at the national level and state wise for Andhra Pradesh, Karnataka, Orissa, Maharashtra and West Bengal for the period 1995-96 to 2009-10. The instability at the national level showed 8.49 per cent in area, 29.01 per cent in production and 28.31 per cent in case of productivity. West Bengal state showed that highest instability area (26.48 per cent) and least was recorded in the state of Orissa (13.63 per cent). The highest instability was recorded in the state of Karnataka in production to the tune of 56.44 per cent followed by Andhra Pradesh (44.82 per cent). Karnataka and Andhra Pradesh stood first and second with respect to instability in case of productivity to the tune of 52.03 per cent and 32.12 per cent, respectively.

**Godara and Poonia (2013)** worked on the impact of prices on acreage and income from gram in Haryana. The data related to area, production, yield and prices were obtained from various issues of the Statistical Abstract of Haryana from 1979-80 to 2008-09. The period from 1979-80 to 2008-09 had also been split up into three decades study of which revealed that the growth rates of area and production during all the reference periods had been negatively significant. The results obtained also

depicted the worse situation of the price policy as far as concerned with the area allocation under gram crop because the area had been decreasing in spite of providing more prices for the crop.

**Birla (2014)** studied the factors influencing the acreage response in three major gram producing state, namely Madhya Pradesh, Maharashtra and Rajasthan for the period 1974-75 to 2008-09 by working on response of chickpea in India. Acreage analysis revealed that price factors were important in Madhya Pradesh and Rajasthan whereas non-price factors were important in Maharashtra. Importance of price factors in Madhya Pradesh and Rajasthan whereas non price factors in Maharashtra.

**Pichad *et al.* (2014)** studied the performance of chickpea in Amravati district carried out with the objectives of growth rates and variability in area, production, and productivity of chickpea. The secondary data on area, production and productivity of chickpea in Amravati district were collected from various issues of the periodical Epitome of Agriculture and district socio-economic reviews for the period of 20 years; the selected period was divided in two, i.e. Period I (1990-91 to 2000-01) and Period II (2001-02 to 2009-10). The performance of chickpea was estimated by using the co-efficient of variation of area, production and productivity of chickpea. Their results revealed that, instability in chickpea area exhibited less variation than production and productivity, during the twenty year period whereas; production witnessed highest instability as compared to area and productivity, for the twenty year period.

**Boyal *et al.* (2015)** attempted to find out the acreage response function of cumin crop in selected districts of Rajasthan and for the state as a whole for the period I (1991-92 to 2000- 01), period II (2001-02 to 2010-11) and overall period (1991-92 to 2010-11). Cumin spice was found to have both pushing and pulling factors, almost equal in number as revealed in the result. The lagged area and price, current and lagged year rainfall, current irrigated area and variability in yield responded in positive direction to boost up area under cumin.

**Kathale *et al.* (2015)** evaluated growth and instability of gram crop in Nagpur division. The production and productivity instability for selected pulses crops were observed in almost the entire districts of Nagpur division. The study was based on secondary data that pertained to the periods 1983-84 to 2012-13 using Coefficient of

variation as measure of instability in production and productivity. Their result revealed that the overall area and production instability was 43.07 and 27.30 per cent respectively in the division. It may be because the crop largely depended on vagaries of nature and that selected pulses production was subject to fluctuation from year to year and thus, causing heavy losses. Farmers could not bear risks due to scarce resource and small holding. A crop failure meant not only the loss of farmer's income but also the loss of investment towards the next crop season. This led farmer to live under debt. In almost all the studied districts, the yield effect was found to be most responsible factor for increasing production in the Nagpur division. However, there was scope to increase yield in rainfed farming by introducing new development program and increasing the technical efficiency at farm level.

**Mishra *et al.* (2015)** worked on supply response of arhar and gram in eastern region of Uttar Pradesh. The study was carried out to investigate the relative impacts of various factors on acreage response of different pulse crops by analyzing time series data from 1970-2012. Using supply response model results revealed that the area under pulse crops was decreasing at an alarming rate. Its price was also increasing but farmers were not getting fair remuneration. This indicated that farmers did not have proper incentives to adjust to desired pulse area. Short and long run elasticities had also been calculated to show price responsive behaviour of farmer.

**Uddin *et al.* (2015)** made an attempt to measure the change and instability in area, production and yield of pulses in Bangladesh based on secondary data during the period 1986 to 2009 collected from Bangladesh Bureau of Statistics using Cuddy Della- Valle Index for analysis. The analysis revealed that the area and production of pulses had not increased satisfactorily. Though the yield of pulse had increased but it was not sufficient to meet the demand for the country's population. The analysis also revealed that the area, production and yield of pulses were not stable during the study period.

**Dash *et al.* (2017)** conducted a research to analyse the growth and instability in pulses production of Odisha during study period (1970-71 to 2013-14) which had been divided into pre-reform (1970-71 to 1991-92) and post reform (1992-93 to 2013-14) period. Coefficient of variation was used as a measure of instability. The authors found an increase in instability of area, production and yield of pulses during both the periods. However, the increase in period II over period I was not found significant. In

case of area, production and yield of rabi pulses, their study showed high instability which could have been due to the fact that the policy decisions of growing rabi pulses had varied from year to year.

**Sood (2017)** conducted research on growth performance of pulses in Rajasthan aimed to study the instability in area, production and yield with structural changes in economic parameters of the selected pulse crops. The secondary time series data covering the period from 2000-01 to 2014-15 were collected and analyzed. During the period 2000-01 to 2014-15, the magnitude of instability in area was higher for black gram (30.79%) while for chickpea, pigeonpea and green gram it remained within the acceptable range of instability i.e. 12.29 per cent, 12.33 per cent and 16.96 per cent, respectively. The magnitude of instability in production for all selected pulses was on the higher side but production of green gram with instability of 61.34 per cent was more unstable compared to the other selected pulse crops. Trend eliminated coefficient of variation values in yield was the highest for green gram (52.04%) followed by black gram (33.14%) and the lowest was observed in chickpea (19.67%).

**Ahmad *et al.* (2018)** studied growth and instability in pulses in eastern India based on secondary time series data concerning the area; production and productivity of lentil crop for the period from 2000-01 to 2015-16. Instability was measured by coefficient of variation. The results of instability indices in area (4.10), production (12.56) and productivity (11.22) of total pulses were recorded lower, indicating that these were comparatively stable in the region under study.

**Bairwa *et al.* (2020)** conducted a study on inter temporal production performance of pulse crops: in Indian context. The study was based on secondary data. The study divided in three period viz. period-I (1998-99 to 2007-08), period-II (2008-09 to 2017-18) and period-III (1998-99 to 2017-18). It was revealed from the results that during overall period the highest instability of 23.12 per cent was recorded for production of green gram followed by 22.38 per cent in lentil production.

**Bairwa *et al.* (2021)** conducted a study on variability and sources of growth in major oilseeds of Rajasthan. The study based on secondary data from 1990-91 to 2019-20 was divided into three periods viz., period-I (1990-91 to 2004-05); period-II (2005-06 to 2019-20) and overall study period (1990-91 to 2019-20). Time series data

were collected from various government e-sources to compute the variability in oilseed production. It was observed from the analysis that the highest instability (31.78%) in production was reported in period-I for kharif oilseeds and the lowest instability (8.42%) in yield was observed in period-II of total oilseeds.

Above cited review showed that the highest instability was found in production while the lowest instability was noticed in area and medium instability was observed in productivity. The lagged price and lagged area of the crop were major instrument to cause in instability in area while instability in productivity was found due to rainfall, lagged rainfall etc.

#### **2.4 Seasonal price Behavior of pulse crops**

**Gowda *et al.* (1988)** studied the marketing arrivals and prices of groundnut and estimated price indices, trend equation and co-efficient of variation for the Gadag and Hubli regulated markets for the period between 1960-61 and 1983-84. They indicated seasonal pattern of market arrivals of groundnut crop and suggested measures like finance, warehouse facilities and market information to eliminate seasonality.

**Kainth and Mehta (1988)** studied various components of time series and relationship between arrivals and prices of potato in Amritsar market. It was observed that there was high seasonal variations and positive trend on arrivals and prices over time. Arrivals and stock of the products in the market affected its price to a great extent. Study concluded that the change in supplies of agricultural products was the most important single factor responsible for wide fluctuations in agricultural product prices and pinpointed that the changes in demand as a result of change in population, income, habits, customs and establishment of processing industries for the commodity were the other important factors responsible for positive trend in price of the commodity.

**Parthasarathy *et al.* (1988)** studied price behavior of vegetables, particularly tomato and brinjal, in Hyderabad market observed that increase in arrivals in general did not show any decline in the prices. Wide fluctuations were noted in arrivals and prices from month to month. Price variations were not of uniform magnitude in the same months in different years as revealed from the study on price

behavior of tomato & brinjal. No perceivable direction in the case of tomato was indicated in the trend.

**Raghu and Satyanarayana (1988)** used conventional time series analysis to estimate the seasonal price fluctuations of eggs price variations and price spread in poultry egg market in Nellore district of Andhra Pradesh. The study revealed that during summer months, the seasonal indices were lower but were higher during winter. The various reasons for the downward trend of prices of eggs in summer months was the unfounded belief prevalent among the consumers that the heating affects the eggs and genuine fears about the quality of eggs.

**Sharma *et al.* (1988)** used time series analysis in studying the structure and behaviour of prices of Himachal apple in Indian market using the method of linear trend and seasonal indices. The study indicated that apple prices showed day to day and month to month fluctuations because of variations in demand, arrivals and stock position in the market. The seasonal behaviour of apple prices was more or less similar for the different markets, *viz.*, Shimla, Delhi, Calcutta, Bombay and Madras. The study further explained that price indices varied widely in Delhi market which was the biggest distribution market for apple in India. The coefficient of variation in apple prices was the highest for Delhi, followed by Shimla, Calcutta and Madras.

**Singh (1988)** studied the market arrivals and prices variability of soybean in main mandies of Uttar Pradesh by using conventional method of time series analysis which indicated that market arrivals of soybean were higher during the period 1986-87 compared to 1983-84. The trend of market arrivals confirmed that a bulk of the soybean was not transacted in the mandies due to lower prices. Suggestions for improvement of the soybean marketing was that government should develop a system to procure the bulk of soybean at a pre-announced purchase price to encourage the soybean growers.

**Viju (1988)** studied the variability in prices particularly that of pepper and ginger in Kerala, showed that the pepper and ginger commodities recorded positive growth rates in the whole period. Intra-year price analysis exhibited that the seasonal index for ginger was the lowest (87.96%) in December, which was coinciding with the harvesting season and it was the highest (108.61%) in June and the range of

seasonal index was 20.65. In case of pepper, the seasonal index ranged from 92.72 in March to 106.46 in July.

**Gill and Singh (1989)** studied the trend and seasonal variations in the prices of groundnut in different districts of Punjab using a multiplication model of time series, which showed the presence of high seasonality effect in the prices and arrivals of groundnut and an inverse relationship between price of groundnut and its arrival. The changes in production technology and price incentives were the main determinants of variation in arrivals. The trend showed that there was a negative coefficient for arrival of groundnut indicating that the arrivals of groundnut had been decreasing while positive coefficient for price indicated an increasing trend of price over the study period. It was concluded that the major reason which compelled the farmers to sell their produce was the low retention power and immediate cash requirements.

**Kuchhadiya et al. (1989)** studied the variability in farm-harvest prices of different crops in Saurashtra region of Gujarat state during 1960-61 to 1986-87. The variability measured in terms of coefficient of variations in farm-harvest prices was 99.73, 68.79, 66.56, 62.67 and 54.37 per cent for sugarcane, groundnut, gram, sesame and castor, respectively. Maize, wheat, paddy, cotton, pearl millet and sorghum recorded less than 50 per cent variability in farm-harvest prices during the study period.

**Sangwan (1989)** used time series analysis to compare the pattern of seasonal fluctuations in potato price in country's important markets. It was observed that there was different seasonality in prices of potato in different markets. He concluded that prices were low and relatively stable during the months of December to March and then there was a sharp increase till the month of July. It was also observed that among the five markets viz., Delhi, Farrukhabad, Meerut, Kanpur and Patna, the level of seasonal fluctuations were the least in Delhi market, followed by Patna, Kanpur, Meerut and Farrukhabad markets.

**Agarwal and Sharma (1990)** studied the price behavior of pulse crops in Rajasthan. Trying to estimate inter-year and intra-year price fluctuations of pulse crops using conventional time series technique. The study revealed that coefficient of average seasonal price index variation was the highest for gram among the different

pulse crops, followed by moth, arhar, moong and urad crops. The study further indicated that the inter-year and intra-year price variation in pulse crops during the study period were in considerable magnitude and that prices increased at an alarming rate for all pulse crops during study period 1974-75 to 1989-90. Prices also exhibited seasonality in their behavior. They gave recommendation that there was a need to control the prices of pulse crops by adopting measures of increasing their production by use of new technology as well as by adoption of different price instruments to regulate their prices.

**Mundinamani *et al.* (1991)** studied the seasonality in arrivals and prices of groundnut during 1965-1966 to 1990-1991 for six markets of three districts of Karnataka. The existence of seasonal fluctuations in arrivals and prices was found in all the studied markets. The seasonal indices for groundnut arrivals were observed to be higher (207.24 to 455.51) immediately after harvest in all the studied markets. Raichur and Ranbennur markets exhibited two peak periods – one after kharif harvest and the other after summer harvest. The rest of the markets had one peak period which corresponded to post harvest months of kharif crops for Bijapur, Talikoti and Gadag markets. In case of Gangavati market it corresponded to post harvest month of summer crops. The price indices of groundnut ranged from 93.37 to 104.65, 86.59 to 109.42 and 87.94 to 109.25 for Bijapur, Talikoti and Gadag markets, respectively. Further, negative values of correlation coefficients indicating the inverse relationship between arrivals and prices for all the studied markets for the period 1979-1980 to 1990-1991 was observed.

**Newadkar *et al.* (1992)** reported in their study on arrivals and prices of tur and gram commodities in Pune regulated market of Maharashtra that there was a wide fluctuation in the arrivals of tur in the market which may be attributed to the decline in the area under the crop which resulted in low production. There was no specific trend in the arrivals of gram. The increasing trend of average prices was observed in both the pulses, however the price of tur had slightly declined during the year 1984-85.

**Basavaraja (1993)** studied the movement of prices and arrivals of major crops viz., jowar, bajra and groundnut in Bijapur using the moving averages and linear trend to analyze the data. The study revealed the presence of upward trend during the period under consideration and the seasonal character was more

pronounced in the case of arrivals than in the case of prices. It was suggested that elimination short term price instability could be done by provision of finance and storage facilities to those farmers who were unable to streamline their supply in accordance with the seasonal variations.

**Dhilion and Goel (1993)** analyzed the seasonality of market arrivals and prices of onion in Ludhiana thereby revealing in the studies that there was high seasonal variation in prices and arrivals of onion in the period under study. Prices were very low during main harvest season, which led to a degree of uncertainty to the farmers' income. During off-season, the prices were very high, thus affecting the consumers adversely.

**Patel and Agarwal (1993)** studied the inter-year price variation for groundnut crop and found that during the one and a half decade, prices increased by more than 10 per cent per annum in the different markets of Gujarat state. Prices of the crop also exhibited notable seasonality during the study period depicting a need to minimize price rise for this commodity. This would be done by adopting measures of increasing their production through use of modern location specific technology as well as by adoption of different price instruments to regulate their prices. Suggestion on check on the tendency of the farmers of brisk sale in the immediate postharvest months by enhancing storage and credit facilities along with the proper education and better price information system were given.

**Babar and Lohar (1994)** studied the trends in arrivals and prices of Jaggery in Sangli regulated market which showed an increasing trend over the period of years. It was also observed that seasonal indices of arrivals of jaggery were higher during the months of August to January, while indices of prices were higher during the month of October, August and September.

**Prakash and Srivastava (1994)** conducted a study on pattern of market arrivals and price of gram in Uttar Pradesh reporting that the inter year variation in market arrivals of gram varied between 86.6 and 120.0 per cent from average annual arrivals from 1987-88 to 1991-92. The variation in market arrivals were not directly related to the annual production of gram in the state. The lowest market arrival of gram was recorded during 1988-89 though there was maximum production of gram in the state during that year.

**Nandal and Hasija (1995)** conducted a study on marketing pattern and price behaviour of gram in Bhiwani district of Haryana and observed that arrivals during the post harvest period were maximum in all the markets, with the passage of time the arrivals proportionately decreased in lean period and increased in mid period.

**Singh et al. (1995)** analyzed the seasonal price fluctuations for wheat in Bihar during the period 1980-81 to 1989-90 and concluded that the trends of prices were similar in both primary and secondary markets i.e. lowest during peak marketing period (April to July) followed by mid (August to November) and lean period (December to March). The seasonal variation in arrivals of wheat was more apparent in primary markets than in secondary markets. It was revealed as that one third of variations in annual arrivals of wheat was governed by the variation in prices in both the primary and secondary markets.

**Kasar et al. (1996)** studied behaviour of prices and arrivals of red chillies in Maharashtra. Seasonal indices of arrivals of red wet chillies begin in October and end in April, where as that of red dry chillies start in May and end in September. The arrivals of red wet chillies were maximum during December to March when the corresponding prices were relatively low. The arrivals of red wet chillies were low during October, November and April. During these months prices were relatively at higher level. By and large, it appeared that when the seasonal index of arrivals of red wet chillies was more during December to March, the seasonal index of prices was at a low level. On the other hand, when the seasonal index of arrivals of red dry chillies was low (May to September) the price index of chillies was at a very high level.

**Miprannavar and Gummagolmath (1998)** analyzed the seasonal indices of arrivals and prices of potato in regulated markets of north Karnataka based on the data on monthly arrivals and prices for the period of 1984-85 to 1994-95 collected from Belgaum and Hubli markets. The long-run trends in arrivals and prices of potato for the selected markets were analyzed using three years moving average method. The study concluded that arrivals were highest in the month of November in both the markets indicating glut during harvesting season. However, price did not decrease during glut season as majority of the traders purchased potato at that time in Belgaum market while there was a negative relationship between arrivals and prices in Hubli market.

**Handiganur and Kunnal (1999)** studied trends in chickpea arrivals and prices in six markets in Karnataka, India during the period 1977-78 to 1996-97. Chickpea arrivals witnessed a continuous upward movement in all the markets, except in Bhalki. The indices of arrivals were higher in the months of February, March, April and May as these months coincided with the post harvest period. A positive relationship was revealed in the markets between arrivals and prices. Price indices in general fluctuated more than arrival indices. There was a greater temporal integration of the Dharwad, Bidar, and Bhalki markets with respect to price formation. Variation in arrivals was more as compared to variation in prices indicating no integration of markets with respect to arrivals.

**Lal et al. (2000)** studied the behaviour of prices and market arrivals of food grains in Himachal Pradesh and revealed that the wholesale prices of principal food grains were increasing overtime. The price of rice showed the highest trend value followed by that of maize and wheat. As expected, the study of seasonal movements in prices and arrivals revealed that the prices of food grains were the lowest during the post-harvest period and these were higher during the lean season. The seasonal indices of market arrivals were also found to be greater than average during the lean period. The prices and arrivals were found to be inversely related to each other. It was concluded that the market arrivals was not only the sole factor of variation in prices but the demand for food grains also attributed to it.

**Patel (2000)** studied the price behaviour of rapeseed and mustard in Mehasana district of Gujarat. The inter-year price variation for rapeseed and mustard crop revealed that during the last one and half decade, prices increased by more than 9 per cent per annum in different markets of Gujarat state and the prices exhibited conspicuous seasonality which necessitated the need to minimize the price rise by adopting measures of increasing production through use of modern location specific technology as well as by adoption of different price instruments to regulate their prices.

**Prakash et al. (2001)** in their study analyzed the inter and intra year variations in market arrivals and prices of wheat in all the regulated markets of Utter Pradesh during the period 1990-91 to 1999-2000. The study revealed that annual variability in price was more than that of arrivals of wheat. Inter-year variation in market arrivals ranged from 88.53 to 113.33 per cent while intra-year variations ranged from 52.36

per cent to 278.14 per cent derived from the average arrivals. A total of 58.52 per cent arrivals reached the market during April to June when prices were low. Inter year variation in wholesale market price ranged between 58.59 and 147.95 per cent. On selling wheat in the regulated markets of U.P., the farmers got more price than the minimum support/procurement price during study period. Negative coefficient of correlation between market arrivals and prices was also observed.

**Ravi Kumar *et al.* (2003)** studied the seasonal variations in monthly arrivals and prices of groundnut for Anakapalle market of Andhra Pradesh for the period 1982-1996 indicated the existence of a definite seasonality in arrivals and prices. A large gap was noticed between seasonal high and seasonal low indices of arrivals and prices of groundnut. Seasonal indices varied from 7.25 to 289.72 and 91.02 to 107.18, respectively of arrivals and prices. The highest seasonal indices of groundnut arrivals and prices were recorded for the months of October and May, respectively.

**Takle (2002)** studied the behaviour of market arrivals and prices of rabi jowar for the period 1981 to 1995 for seven regulated markets of Marathwara region i.e. Aurangabad, Jalna, Parbhani, Beed, Latur, Osmanabad and Nanded. Analyzing the seasonal variations of arrivals that showed a higher degree in Jalna market and lower degree in Osmanabad and Parbhani markets. Price of rabi jowar varied to greater extent in Prabhani market and to a smaller extent in Nanded market. The annual variation in prices was found to be highest in Latur and Beed market and lowest in Nanded and Parbhani market. It was also observed the high negative relationship between arrivals and prices of rabi jowar in selected markets.

**Singh and Kumari (2003)** studied monthly time series data on price and arrivals of rice from the selected regulated markets of Bihar for the period 1990-91 to 2000-01 and observed that the arrivals of rice in Narkatiaganj, Bihariganj and Musallapur regulated markets was almost evenly distributed throughout the year. However, in primary markets of Narkatiaganj and Bihariganj, more arrivals were observed during peak period followed by mid and lean period. Similar trend of price was observed in all selected markets i.e. lower during post harvest months and higher during lean period.

**Chahal *et al.* (2004)** studied the price behaviour of green peas in Hoshiarpur and Ludhiana (Punjab) markets from the year 1994 to 2002 and found positive

correlation coefficient of arrivals of peas in Ludhiana market; whereas negative in Hoshiarpur market. They also found that correlation coefficient of prices of both the markets were positive. The price analysis of peas showed that the seasonal indices of prices were the lowest during the peak harvest season. The perishability of the produce could be attributed as the main reason for it. The market arrivals remained almost constant in Hoshiarpur market while these have undergone increase overtime in Ludhiana market. The reason for increasing trend in the latter market may be due to its locational advantage and higher demand which attracted the sellers and buyers from nearby areas in spite of the fact that area allocated to green peas was comparatively lower as compared to Hoshiarpur market. In both the markets direct sales to consumer had turned out to be the most efficient sales outlets, which was a clear indication for the elimination of the intermediaries. This could be achieved through group marketing, cooperative marketing and/ or contract farming.

**Agbogo and Tiku (2004)** studied the price behaviour of four selected agricultural products (rice, beans, garri and yam) in Ogojo and Yala Local Government Areas in Cross River state, Nigeria. The study revealed that prices of garri and yam were found to be the highest between May and August at both terminal markets, while December to March was the main peak of the glut for both crops. For rice and beans, Okuku was found to be a feeder-market to Mbube, with prices being the highest at both markets from May to August. Various statistical tests carried out in addition to the trends revealed by the line graphs confirmed that much of the price variations, in addition to responses to general and specific demand forces, were due to the seasonal and biological nature of the agricultural products. The study revealed further that those farmers who were able to hold their stock up to August could make more from the sale of these products at both markets.

**Kumar *et al.* (2005)** studied the behaviour of market arrivals and prices of major vegetable crops in four metropolitan markets of Delhi, Mumbai, Bangalore and Kolkata from 1990 to 2001 and revealed that in cabbage, the extent of variability in arrivals was lower in Bangalore and higher in Mumbai. Prices were relatively stable in Mumbai but were volatile in Bangalore. There was broadly a similar pattern in the prices across different months in Kolkata and Delhi markets. The authors also found relationship between market arrivals and prices over the years in all the four

metropolitan markets. Across different months, there were several instances of positive relationship between arrivals and prices in all the four markets.

**Kumar *et al.* (2006)** studied the market arrival and price behaviour of potato in four metropolitan markets (Delhi, Bangalore, Mumbai and Kolkata) for the period 1990-2001 to reveal that as regards the market arrivals, in Bangalore market the variability was higher than that in Delhi and Mumbai markets. The price variability was maximum during August-September in Delhi and Bangalore markets, during July-October in Mumbai and during May- July in Kolkata markets. While the relationship between market arrivals and prices in Delhi market was found to be positive, it was negative for Mumbai, Bangalore and Kolkata Markets. The correlation coefficients were mostly statistically non-significant.

**Kaur *et al.* (2006)** analyzed the seasonal fluctuations and price trend for green pea in Punjab for the period 1994 to 2003 and observed that when arrivals were high, the prices ruled low and when arrivals were low, the prices ruled high. The arrivals in the peak season were high as compared with those in the mid and lean seasons indicating seasonality of the crop, lack of storage and processing facilities and low holding capacity of the farmers. The higher price indices were observed during the month of July to November and the lowest for March and kept less than hundred from December to June.

**Khunt *et al.* (2006)** studied the seasonality in arrivals and prices of all the major vegetables produced in Gujarat state and an inverse relationship was observed between prices and arrivals of most of the vegetables. Arrivals and prices of major vegetables were increased over the period in most of the regulated markets showing the scope for expansion of vegetable cultivation. Lack of storage facilities in the state was observed in the study.

**Garg and Bhakar (2006)** examined the market efficiency and economic profitability for wheat crop in the regulated market at the Bikaner district of Rajasthan based on the time series data for the past ten years drawn from four regulated markets, which covered more than 95 per cent of the total arrivals of the whole district. The study clearly indicated that the annual prices of wheat increased significantly whereas arrivals in the market, though increased, were not significant. The monthly prices for wheat crop also showed an increasing trend, implying thereby the growth of market.

On the basis of seasonal indices, the study revealed that the consumers could be advised to purchase wheat from Bikaner in August, from Nokha in October, from Loonkaransar in April and from Khajuwala in June. November- December was shown as the perfect time for the sale of wheat by farmers, as observed in the study.

**Kumari (2009)** studied the seasonal fluctuation in price of maize in the Karimnagar and Nizamabad regulated markets of Andhra Pradesh. Indices of wholesale price of maize during 2002 – 2007 period was worked out showing that the seasonal price indices were the highest in the month of August followed by July in both the markets mainly due to less arrivals of early sown crop. Significant variation between months and non-significant variation between markets were indicated in the analysis of variance regarding pricing pattern in these two markets. The correlation coefficient (r) value of 0.52 between the two market prices indicated a positive and significant (significant at  $p < 0.1$ ) relationship in the movement of maize prices in both the market.

**Shelke *et al.* (2009)** studied supply response relationship in order to examine the effect of yield and price variability on the acreage allocation to chickpea crop in which the coefficient of variation of yield and price of chickpea crop were included in estimating equation and Cobb-Douglas and Linear forms. The results revealed that lag acreage significantly affected the chickpea acreage in Marathwada where an increase variation in past prices of chickpea crop reduce area allocation in this crop. However in some cases there was an autonomous increase in chickpea area over the period of time.

**Taru *et al.* (2009)** studied the price behavior of maize and guinea corn in Michika and the local government area of the Adamawa State of Nigeria, within a year and determined how farmers curb price risks. Simple descriptive statistics and time series model were used in analyzing the data. The results showed 80.68 and 94.57 per cent of maize and guinea farmers, respectively, curb price risks by crop income diversification, while time series analysis indicated that seasonal variations exist which were more prominent and hence dominate.

**Chaudhari and Pawar (2010)** studied seasonal variation and relationship between market arrivals and prices of pigeon pea for the period 1985-86 to 2004-05 from four APMC viz., Latur, Udgir, Osmanabad and Paranda in Marathwada region

of Maharashtra State. The maximum arrivals of pigeon pea were recorded in the month of January in all selected markets, while significant negative relationship was observed in latur market between arrivals and prices of pigeon pea.

**Kolur *et al.* (2012)** studied the market arrivals and prices behavior of wheat in Bagalkot, Bijapur, Belgaum, Dharwad and Gadag markets in Karnataka from 1989-90 to 2009-10. The time series data indicated a raising trend and trend coefficients of arrivals and prices were found to be significant. The results of long-term movements of arrivals showed significant at 5 per cent level of significance in Dharwad, Bagalkot and Gadag markets while at 1 per cent level of significance in Belgaum and Bijapur. Seasonal fluctuations was also analyzed and revealed that during January there was the lowest arrivals in the market and prices were the highest in February.

**Salam *et al.* (2012)** studied the seasonal price fluctuation and spatial price relationship of major cereal crops viz., Boro paddy and wheat in different markets in Bangladesh and found that crops prices fluctuated in different months within the year. The difference between peak and trough price as well as coefficient of variation was higher for Boro paddy than wheat. The results of empirical evaluation of spatial price linkage through Engle-Granger co-integration method among regional selected markets of Bangladesh using harvest price of Boro paddy and wheat indicated that these markets were well integrated. Which indicated that, information about price changes were fully and instantaneously delivered to the other markets in Bangladesh.

**Anoop Kumar (2014)** studied the Intra-year price instability of commercial crops in India and concluded that even in the scenario of integrated market setting price instability at the intra-year level was guided mainly by the seasonal character of supply. Hence, market offered high price to the farmers only when they had less to offer in the market and vice versa, which made their income unstable in the short run. This highlighted the fact that there was the need for stabilizing producers' returns.

**Dhakre and Bhattacharya (2014)** conducted a study to know the statistical investigation of price behaviour of potato in Agra analyzing the Potato wholesale prices of Agra market using univariate ARIMA (2,1,1) model. Seasonal indices calculated showed that generally the price was low from November to January

and it started picking up from February, and reached the maximum in November. The accuracy measures like MAPE and MSE were considered as the best models to forecast monthly prices. Among all the models, ARIMA (2,1,1) model was the best with least Mean Average Percentage Error (MAPE) and Mean Square Error (MSE) value for Agra 20.57 and 102.22, respectively.

**Dave and Tarpara (2016)** studied the price behavior of major pulses in Gujarat state. Monthly wholesale prices were taken for three regulated market for each crop. The prices of all the pulses were taken from the year 2003 to 2013. The prices of all the pulses with their respective markets experienced unremitting price fluctuation and indicated high degree of year to year variability in the all markets under the study. It was found that there was lower fluctuation in the period 2003, 2004 and 2013 while remaining years showed moderate to very high fluctuations of intra year variability in all the markets.

**Devi et al. (2019)** conducted a study on price and arrivals pattern and market integration of major pulse crops i.e. gram and tur in Gujarat state. The secondary data on monthly arrivals and wholesale prices were collected from the website of [agmarknet.gov.in](http://agmarknet.gov.in) of selected regulated markets for ten years (2007-2016). The research indicated that the inter-year price analysis showed upward trend of price indices and there was significant increase in the price of gram and tur in the all selected market. The intra year price analysis revealed that the general pattern of seasonal variations in prices were found with increased prices in off season and decrease in main season all most in all the selected markets in the both crops. The pattern of arrivals shows that the quantity of arrivals was more in off season in the selected markets. This may be due to the stockiest released their stocks with the commencement of new season.

**Islam et al. (2020)** conducted a study on seasonal price fluctuations of paddy in Bangladesh using monthly average wholesale price of paddy over a period from 2001 to 2019. Secondary data were used in the study and collected from different secondary sources. The multiplicative model was used in the study; the least square method was applied to find out the long-term changes occurring in the price of paddy and the ratio to moving average method was used to measure seasonal fluctuation in prices of paddy. It was observed from the study that seasonal price fluctuations of paddy prevail in Bangladesh as seasonal indices. April to August, the price of paddy

was lower compare to other months price because April and May was the harvesting period of paddy and resulted in more arrivals to the market. From August, arrivals was increased gradually and reached to the peak position on March with 112.15 per cent.

It is apparent from the previous literature review that a large number of studies have been conducted to assess. As the coefficient of variation of prices increased then the degree of stability of prices decreased. The variability in arrivals, affect the demand and the price to a great extent. Keeping such variations in demand in view, the growers can obtain better prices by matching supply to the market requirements during the period of high seasonal price index.



### 3. MATERIAL AND METHODS

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This chapter describes the methodology adopted for the selection of crop, region, markets, collection of data as well as the analytical tools and techniques used to arrive at the stated objectives. For the sake of convenience, the methodology has been presented under the following heads:

- 3.1 Description of the study area
- 3.2 Selection of area
- 3.3 Selection of districts
- 3.4 Selection of markets
- 3.5 Selection of crops
- 3.6 Study period and database
- 3.7 Analytical framework

#### **3.1 Description of the study area**

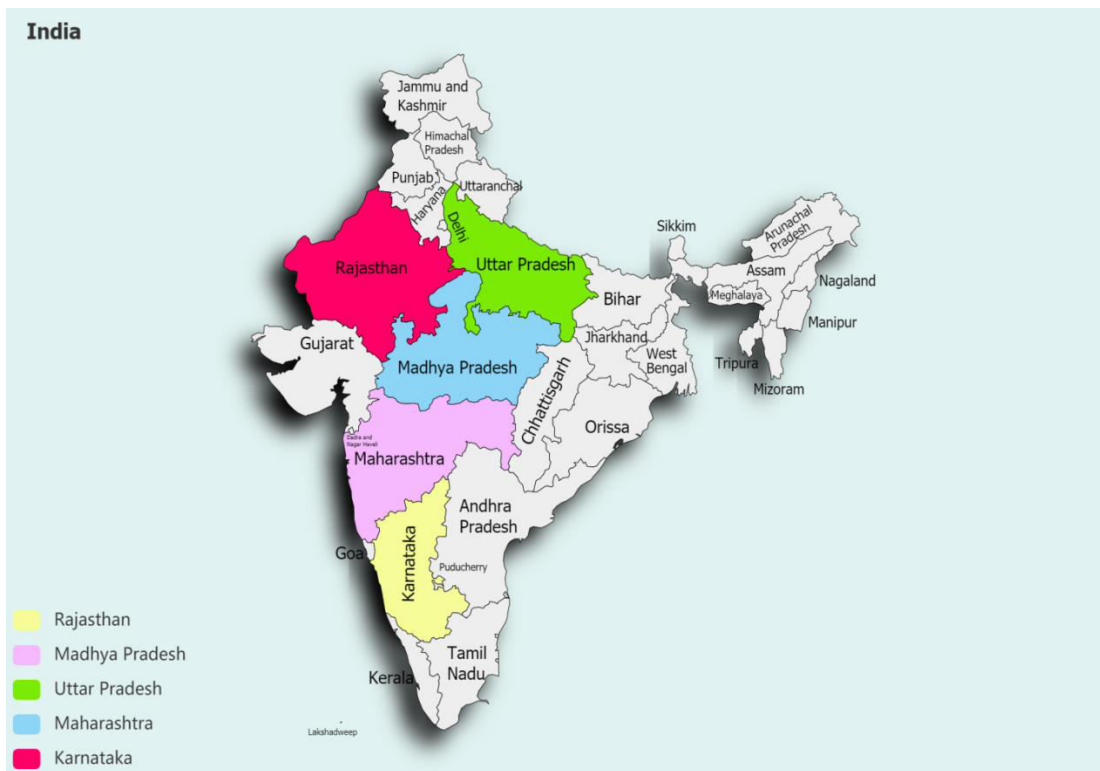
**Rajasthan-** Rajasthan lying between 23° 30' and 30° 11' North latitudes and 69° 29' and 78 ° 17' East longitudes in the north western part of India. Rajasthan is indeed one of the biggest states in the country. Rajasthan has an extensive area of 3, 42,239 sq.km comprising of 11 per cent of the total geographical area of India. The extensive topography includes rocky terrain, rolling sand dunes, wetlands, barren tracts or land filled with thorny scrubs, river-drained plains, plateaus, ravines and wooded regions. Rajasthan experiences extreme climate or weather and consists of four distinct seasons- Pre-monsoon, Monsoon, Post-monsoon and Winter. The average temperature in winter ranges from 8° to 28° C (46° to 82° F) and in summer the average temperature ranges from 25° to 46° C (77° to 115° F) making the region parched and draught-prone.

**Madhya Pradesh-**Madhya Pradesh literally means "Central Province", and is located in the geographic heart of India in between the latitude of 21.6°N–26.30°N and longitude of 74°9'E–82°48'E. The state straddles the Narmada River which runs east and west between the Vindhya and Satpura ranges; these ranges and the Narmada are the traditional boundaries between the north and south of India. The highest point in Madhya Pradesh is Dhupgarh with an elevation of 1,350 m (4,429 ft). Madhya



Pradesh has three major seasons – Summer, Monsoon and Winter. During summer (March–June), the temperature in the entire state ranges above 29.4°C. In general, the eastern parts of Madhya Pradesh are hotter than the western parts. The regions like Gwalior, Morena and Datia record temperature of over 42°C in the month of May.

**Uttar Pradesh-** with a total area of 243,290 square kilometres (93,935 sq miles), is India's fourth-largest state in terms of land area and is roughly of same size as United Kingdom. It is situated on the northern spout of India and shares an international boundary with Nepal. Uttar Pradesh situated between 23°52'N and 31°28'N latitudes and 77°3' and 84°39'E longitudes, this is the fourth largest state in the country in terms of area, and the first in terms of population.



**Figure 3.1: Selected states of India**

**Maharashtra**-is the third largest state in the country and covers a geographical area of 308,000 square km. Maharashtra has a tropical climate, with three distinct seasons: summer (March–May), monsoon (June–September), and winter (October–February). However, dew and hail also occur sometimes, depending on seasonal weather. The winter between October to February is followed by summer between March and May and the monsoon season between June and September. Summers (March, April and May) are extremely hot, temperatures rising from 22 °C to as high as 43 °C. Rainfall



starts normally in the first week of June. July is the wettest month in Maharashtra, while August also gets substantial rain. The rainy season starts its retreat with the coming of September to the state. Rainfall in Maharashtra differs from region to region.

**Karnataka**-The Indian State of Karnataka is located 11°30' North and 18°30' North latitudes and 74° East and 78°30' East longitude. It is situated on a table and where the Western and Eastern Ghat ranges converge into the complex, in the western part of the Deccan Peninsular region of India. Karnataka has a total land area of 191,791 km<sup>2</sup> and accounts for 5.83 per cent of the total area of the country (measured at 3,288,000 km<sup>2</sup>). This puts it in seventh place in terms of size.

### **3.2 Selection of the study area:**

#### **Selection of major states**

The pulses cultivation is an integral part of cropping system of the country with the average area of 282.32 lakh hectare and production of 216.11 lakh tonnes (2015-16 to 2017-18.) More than 70 per cent area and production of total pulses is contributed by Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh and Karnataka states, therefore, these states were selected to estimate the trend, decomposition and instability analysis of selected pulses.

Out of 5 States, Madhya Pradesh and Rajasthan were purposively selected for analysis of seasonal price behavior as Madhya Pradesh and Rajasthan are holding first and second position, both in area and production during T.E. average of 2015-16 to 2017-18 as shown in Tables 3.1 and 3.2. The seasonal indices were calculated on the basis of wholesale price of all selected pulse crops in selected states.

**Table:-3.1: Average Production and per cent Share of Major Pulses in Major States of India**

(Production-Lakh tonnes)

States	Production			Average	% Share	C.T. % Share
	2015-16	2016-17	2017-18			
<b>Madhya Pradesh</b>	51.17	62.91	81.12	65.07	30.11	30.11
<b>Rajasthan</b>	19.53	31.80	33.86	28.40	13.14	43.25
<b>Maharashtra</b>	14.10	37.68	33.04	28.27	13.08	56.33
<b>Uttar Pradesh</b>	12.19	21.84	22.08	18.70	8.65	64.98
<b>Karnataka</b>	13.89	17.37	18.55	16.60	7.68	72.67
<b>Others</b>	53.80	59.71	63.70	59.07	27.33	100
<b>Total</b>	164.68	231.31	252.35	216.11	100.00	

Source: Compiled from DES, Ministry of Agriculture &FW (DAC&FW), GoI

**Table: 3.2: Average Area and per cent Share of Major Pulses in Major States of India**

(Area- Lakh hectare)

States	Area			Average	% Share	C.T. % Share
	2015-16	2016-17	2017-18			
<b>Madhya Pradesh</b>	57.62	66.64	74.8	66.35	23.50	23.50
<b>Rajasthan</b>	38.71	52.71	53.29	48.24	17.09	40.59
<b>Maharashtra</b>	33.56	43.58	43.52	40.22	14.25	54.84
<b>Uttar Pradesh</b>	18.65	25.09	22.68	22.14	7.84	62.68
<b>Karnataka</b>	27.8	29.66	30.21	29.22	10.35	73.03
<b>Others</b>	76.25	76.77	75.43	76.15	26.97	100
<b>Total</b>	252.59	294.45	299.93	282.32	100.00	

Source: Compiled from DES, Ministry of Agriculture &FW (DAC&FW), GoI

### 3.3 Selection of District

A list of all the selected pulses producing districts in the Madhya Pradesh and Rajasthan states were prepared to analyze the seasonal price behavior on the basis of

higher production and area coverage. From the list, 5 districts were purposively selected from one state for 5 selected crops (one district for each selected pulse crop) on the basis of highest production.

### 3.4 Selection of Market

A list of price reporting markets for selected pulse crops of each selected district was prepared. Out of the list of price reporting markets for which continuous series of monthly wholesale price data for ten years (January 2008 to December 2017) was considered, 5 markets were purposively selected considering one market for each crop in each selected district under the study.

### 3.5 Selection of major pulse crops:

There are ten pulse crops as gram, pigeon pea, black gram, green gram, lentil, pea, moth bean, grass pea, field pea and horse gram which are mainly grown in the country. The study was based on the gram, pigeon pea, black gram, green gram and lentil pulse crops which contributed more than 85 per cent area and production of total pulses in the country as depicted in Table 3.3 and 3.4.

**Table:-3.3: Average Production and per cent Share of Major Pulses in India**

(Production-Lakh tonnes)

Crops	Production			Average	% Share	C.T. % Share
	2015-16	2016-17	2017-18			
<b>Gram</b>	71.69	92.35	42.73	92.35	42.73	42.73
<b>Pigeon pea</b>	24.58	37.46	17.33	37.46	17.33	60.06
<b>Black gram</b>	21.99	27.72	12.83	27.72	12.83	72.89
<b>Green gram</b>	16.03	18.90	8.74	18.90	8.74	81.63
<b>Lentil</b>	9.80	12.35	5.72	12.35	5.72	87.35
<b>Others</b>	20.59	27.34	12.65	27.34	12.65	100
<b>Total</b>	164.68	231.31	252.35	216.11	100.00	

Source: Compiled from DES, Ministry of Agriculture &FW (DAC&FW), GoI

**Table:-3.4: Average Area and per cent Share of Major Pulses in India**

(Area- Lakh hectare)

Crops	Area			Average	% Share	C.T. % Share
	2015-16	2016-17	2017-18			
<b>Gram</b>	83.49	96.26	105.73	95.16	33.71	33.71
<b>Pigeon pea</b>	37.46	53.87	44.59	45.31	16.05	49.76
<b>Black gram</b>	40.19	44.78	50.31	45.09	15.97	65.73
<b>Green gram</b>	38.32	43.27	40.70	40.76	14.44	80.17
<b>Lentil</b>	12.80	14.50	14.94	14.08	4.99	85.15
<b>Others</b>	40.33	41.77	43.66	41.92	14.85	100
<b>Total</b>	252.59	294.45	299.93	282.32	100.00	

Source: Compiled from DES, Ministry of Agriculture &FW (DAC&FW), GoI

### 3.6 Study period and Database

The time series data of 30 years from 1988- 89 to 2017-18 was used for the proposed investigation.

The arrivals and monthly wholesale price data of 10 years from 2008-09 to 2017-18 were used to analyse the seasonal price behavior of selected pulse crops with selected market.

The study was based on secondary data and the available information was collected from different sources *viz.*, Directorate of Economics and Statistics, Ministry of Agriculture, Indiatat.com, AGMARK and NAFED and Krishi Upaj Mandi Samities.

### 3.7 Analytical Framework

#### **Trend in area, production and productivity of major pulse crops**

To analyse the trend in area, production and productivity of major pulse crops, the following different functional forms were fitted.

1. Linear function
2. Quadratic function
3. Exponential function

### 1. **Linear function**

A linear model is one in which all the parameters appear linearly. The mathematical equation is given by

$$Y = a + bt$$

Where,

Y = Area, production and productivity of major pulse crops

a = Intercept

b and c=Coefficient

t = Variable (Time)

The a and b was estimated by applying the ordinary least square approach

### 2. **Quadratic function**

This function is useful when there is a peak or troughs in the data of past period. Quadratic fit is given by equation:

$$Y = a + bt \pm ct^2$$

Where,

Y = Area, production and productivity of major pulse crops

a = Intercept

b and c=Coefficient

t = Variable (Time)

The a, b and c was estimated by applying the ordinary least square approach

### 3. **Exponential function**

Exponential fit is given by equation

If, when the values of t are arranged in an arithmetic series, the corresponding values of y form a geometric series, the relation is of the exponential type.

$$Y = ab^t$$

Where,

Y = Area, production and productivity of major pulse crops

a = Intercept

b and c=Coefficient

t = Variable (Time)

The a and b was estimated by applying the ordinary least square approach.

The functional form having the highest co-efficient of determination ( $R^2$ ) was selected for fitting the trend. Similarly, the growth rates of area, production and productivity of major pulse crops were also computed.

### **Compound Growth Rate**

Compound annual growth rates was estimated to know the growth pattern on area, production and productivity of major pulse crops in India. The growth rate was estimated by using exponential trend model (Veena, 1996).

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 per cent 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 pulse crops (Dhakre and Sharma 2010).

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

Where,

't' = Student 't' test

CGR = Compound growth rate

SE (CGR) = Standard error of Compound growth rate

Standard error of Compound growth rate was calculated by using following formula (Rao *et al.*, 1981).

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

### **Relative contribution of acreage and yield in production of pulse crops**

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

$$\begin{aligned} \Delta P &= AB * \Delta Y + YB * \Delta A + \Delta A * \Delta Y \\ &= (\text{Yield effect}) + (\text{Area effect}) + (\text{Interaction effect}) \end{aligned}$$

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.

$$\Delta A = \text{Change in area}$$

$$\Delta P = \text{Change in production}$$

$$\Delta Y = \text{Change in yield}$$

### **Instability in area, production and productivity of pulse crops**

An index of instability was computed for examining the nature and degree of instability in area, production and yield of major pulse crops. Simple coefficient of variation does not explain properly the trend component inherent in the time series

data so the instability index was calculated using better measure of variability suggested by Cuddy- Della Valle index (Cuddy and Della, 1978).

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

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

$R^2 = \text{ESS/TSS}$  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 (Sihmar 2014):

Low instability = Between 0 to 15

Median instability = Greater than 15 and lower than 30

High instability = Greater than 30

### **Causes of Instability in area and yield of pulse crops**

Production of pulse crops fluctuates basically due to two reasons: (i) those caused by nature determined uncontrollable climatic factors and (ii) those caused by controllable man made factors.

### **Causes of Instability in Area**

Growers fix area target for pulse crop production which develops from their past experience in bringing actual area under pulse crops. The area target of pulse crops are adjusted every year in response to area of its competitive crops and weather condition. The relative change in the area target from one year to the next, thus depends solely on the area of its competitive crops. In order to examine the causes of instability in the area of pulse crops, following model was used.

$$\text{Log}A_t = B_0 + B_1 \text{log}A_{t-1} + B_2 \text{Log}C_t + B_3 \text{Log}C_{t-1} + B_4 \text{Log}S_t + B_5 \text{Log}S_{t-1}$$

Where;

$A_t$  = Pulse crops area in period t

Where  $B_0$  = Constant

$A_{(t-1)}$  = Lagged area of Main Crop

$C_t$  = Area of Competitive Crop

$C_{(t-1)}$  = Lagged area of Competitive Crop

$S$  = Seasonal Rainfall

$S_{(t-1)}$  = Lagged Seasonal rainfall

Note: All the competitive crops of selected crops were selected on the basis of higher average triannum area (2015-16 to 2017-18)

Competitive crop of gram and lentil was wheat while of black gram, green gram and pigeon pea is pearl millet in Rajasthan was taken.

Competitive crop of gram and lentil was wheat while of black gram, green gram and pigeon pea was soybean in Madhya Pradesh

Competitive crop of gram and lentil was wheat while of black gram, green gram and pigeon pea was paddy in Uttar Pradesh

Competitive crop of gram and lentil was wheat while of black gram, green gram and pigeon pea was cotton in Maharashtra

Competitive crop of gram and lentil was wheat while of black gram and green gram was paddy in Karnataka

### **Causes of Instability in Yield**

The following model was used to estimate the impact of seasonal rainfall changes on pulse crops yield variability.

$$\text{Log } Y_t = B_0 + C_1.T + C_2. \text{Log } S$$

Where,

$Y_t$  = Pulse crops yield in period t

Where  $B_0$  = Constant

$C_1$  and  $C_2$  = Regression coefficient

$S$  = Seasonal Rainfall

## **Seasonal Price Behavior**

For determining the seasonal price behavior, data of monthly whole sale prices were used. Below mentioned approaches were used in order to study the seasonal price behavior.

### **Computation of Seasonal price Indices**

This was calculated from the original (monthly wholesale price) data using seasonal indices. There are at least four methods to calculate seasonal indices from the original data. These are the ratio to trend, the ratio to moving average, simple average and link relative methods. There is a continuous refinement in using these methods. Earlier the method of link relatives was the most prominent method for computing the seasonal indices but now a days, the method of ratio to moving average is preferred over others. For example, in the ratio to trend method, it is impossible to separate the cyclical component from seasonal component. The seasonal indices computed by this method contains cyclical component also. But in case of method of ratio to moving average, this problem does not arise. Therefore, the ratio to moving average method was employed in the study to compute the seasonal price indices. Following steps will be used to compute the seasonal price indices.

Step I: The centered 12 months moving average was computed from the original data. These centered 12 months moving average data contain the trend and cyclical component.

Step II: Divide the original data by the centered moving average.

$$Y = TSCI$$

$$Y/MA = TSCI/TC = SI$$

Step III: The irregular component was eliminated by averaging the data for each month over the years that we will get in step II. After averaging the data and multiplied it by hundred, the resultant was seasonal index for each month.

Step IV: The sum of seasonal indices should be 1200. If it is greater or less than 1200 then it was adjusted by using a correction factor i.e.

$$K = 1200/S$$

Where,

K = Correction factor

S = Sum of seasonal indices

The extent of seasonal price variation was determined by using different measures of intra year price variations. These methods were used to measure the intra year price variations i.e. intra year price rise (IPR), coefficient of average seasonal price variation (ASPV) and coefficient of variation (CV).

### **Extent of Intra Year Price Rise (IPR)**

The difference between the lowest and highest price within the year is termed as intra year price rise (IPR). The price of most commodities usually remain the lowest in the harvest season and rise thereafter till it reach the highest level in the next pre harvest season.

### **Average Seasonal Price Variation (ASPV)**

The average seasonal price variation was computed using the following formula (Verma *et al* 2017).

The Average Seasonal Price Variation was computed using the following formula.

$$ASPV = \frac{HSPI - LSPI}{\left(\frac{HSPI + LSPI}{2}\right)} \times 100$$

Where,

ASPV= Average Seasonal Price Variation

HSPI = Highest Seasonal Price Indices

LSPI = Lowest Seasonal Price Indices

This coefficient has some advantages over IPR and indicates the average variations in prices during the year.

### **Coefficient of variation**

It expresses the variability of the prices of its average. It indicates or measures the stability or instability of given parameter. It was computed by using the formula.

$$\text{Coefficient of Variation} = \frac{\sigma}{\bar{X}} \times 100$$

Where  $\sigma$  is estimated value of standard deviation of seasonal price indices and  $\bar{X}$  is the arithmetic mean of seasonal price indices. Since the arithmetic mean of seasonal price indices is always 100, the standard deviations in its self was the coefficient of variations. The standard deviations and arithmetic mean was calculated by the following formula (Verma *et al.* 2017).

$$\sigma = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n - 1}}$$

$$\bar{X} = \frac{\sum X_i}{n}$$

Where  $X_i$  is the seasonal index for the  $i$ th month ( $i= 1$  to 12) and  $n$  is the number of months, *i.e.* = 12.

## 4 RESULTS AND DISCUSSION

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Commensurate with the objectives of the present study, the results of the study on “Dynamics of Area and Production of Major Pulse Crops in India” are presented in this chapter under four sections for the sake of expositional convenience. The first section deals with trend in area, production and productivity of pulse crops in India. Second section deals with relative contribution of acreage and yield in production of pulse crops over the time. Third section deals with instability in area, production and productivity and to determine the causes of instability and fourth section devoted to examine seasonal price behavior of major pulse crops.

### 4.1 Trend in area, production and productivity of pulse crops in India

The knowledge of growth rates of crop enables one to access the progress and performance of agricultural sector in particular area. Its gives an idea about the allocation of resources in different area and it will helps in remedying regional imbalance through appropriate policy measures. The analysis of growth usually used in economic studies to find out the trend of a particular variation over a period of time and use for making policy decisions and with the objective of promoting balanced regional development strategy. To estimate the trends of growth in area, production and productivity of pulses in India and major producing states, linear, quadratic and exponential function were used.

#### 4.1.1 Growth in Area, Production and Productivity of major pulses in India

The compound annual growth rate of area, production and productivity of gram, black gram, green gram, pigeon pea and lentil in Rajasthan, Madhya Pradesh, Uttar Pradesh, Maharashtra and Karnataka states were computed for selected study periods *viz.*, the period-I (1988-89 to 1997-98), period-II (1998-99 to 2007-08), period-III (2008-09 to 2017-18) and overall period (1988-89 to 2017-18). State wise compound growth rates were presented as follows:

##### 4.1.1.1 Growth rates of major pulses in Rajasthan:

The compound annual growth rates of area, production and productivity of selected pulse crops (gram, black gram, green gram, pigeon pea and lentil) were found not stable during the entire study period in Rajasthan. Therefore, the compound annual growth rates in area, production and productivity of these pulses were

analyzed and presented periodically viz., period-I, II, III and overall from (Table 4.1 to 4.5).

## **Gram**

The results of growth rate in area, production and productivity of gram were presented in the Table 4.1. It was revealed from the table that during entire study period, the area under chickpea was declined at the rate of -0.46 per cent per annum while the production of this crop was non-significantly increased at the rate of 1.86 per cent per annum. At the same time, productivity of gram was significantly increased at the rate of 2.33 per cent per annum in Rajasthan. The production of gram in Rajasthan might be increased due to significant growth in the productivity of this crop. In the mean time, the area under gram might be decreased due to expended in area of its competitive crop lentil.

During period-I, (1988-99 to 1997-98) the area and production of gram were showed significantly increased at the rate of 11.69 and 17.49 per cent, respectively per annum in Rajasthan. At the same time, the productivity was non-significantly increased at the rate of 5.20 per cent annually. The production of gram could be increased due to positive and significant growth in area of grown crop. Further, positive growth in productivity of grown crop could be played a major role in augmenting production of gram.

During period-II, (1998-99 to 2007-08) area, production and productivity of chickpea were showed drastically declined at the growth rate of -5.16, -10.46 and -5.81 per cent per annum respectively in the state. It could be observed from the results that production of gram was declined due to negative growth in area as well as productivity of chickpea crop. During period-III, (2008-09 to 2017-2018) the area, production and productivity of gram were increased at the rate of 2.09, 10.15 and 7.89 per cent per annum, respectively. In period-III, the production could be increased due to significant upward in productivity and non-significant augmentation under area of gram. Kalmakar, (2001), in his study reported similar pattern of growth rate in area, production and productivity of gram in Maharashtra during 1961-62 to 1997-98.

Therefore, it could be concluded from the analysis that during throughout study period, the growth rates in area, production and productivity of gram were represented mixed growth pattern in Rajasthan. During period-I and III, area,

production and productivity were increased over the year. In case of period-II, all aspects *viz.*, area, production and productivity of gram showed a negative growth rates in Rajasthan.

**Table 4.1: Compound annual growth rate of area, production and productivity of Gram in Rajasthan**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	11.69** (0.019)	17.49** (0.029)	5.20 (0.016)
Period- II	-5.16 (0.053)	-10.46 (0.056)	-5.81 (0.024)
Period- III	2.09 (0.029)	10.15 (0.038)	7.89** (0.016)
Overall	-0.46 (0.007)	1.86 (0.009)	2.33** (0.004)

Source: Author's own commutation 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 4.2 it showed the estimation of growth rates in area, production and productivity of lentil in Rajasthan. It was observed from the table that during overall period, the area and production of lentil were recorded positive and significant growth rate in Rajasthan. In this period, the reported growth rate was 12.72 per cent in production followed by 11.94 per cent in area of lentil. On the other hands, the productivity of lentil was increased non-significantly with the magnitude of 0.93 per cent per annum in overall period. In the study, the production of lentil in Rajasthan was increased; it might be due to positive and significant growth in area of lentil.

In the period-I, the area, production and productivity were significantly increased with the extent of 28.53, 40.93 and 9.40 per cent annually, respectively. The period-I attributed significant and remarkable improvement in production of lentil; it could be due to positive and significant growth in productivity and area in lentil. Whereas, the production and productivity of lentil in period-II were declined significantly at the rate of -26.72 and -8.80 per cent per year, respectively. At the same time, the area under lentil was also declined non-significantly at the rate of -

20.02 per cent annually. The production of lentil crop was declined in the Rajasthan, due to negative growth in area and productivity of lentil crop.

During period-III, the highest and significant growth rate was recorded in production (39.96%) of lentil followed by area (38.36%). Further, the productivity of lentil crop was also increased but non-significantly with the magnitude of 1.62 per cent per annum. In the same period, the production of lentil could be increased due to significant and remarkable improvement under area. Similar findings were also reported by Agarwal *et al.* (2012) in area, production and productivity of lentil in India during 1970-71 to 2007-08 period.

Thus, the results presented in table indicated that area, production and productivity of lentil was augmented during period-I, III and overall in the Rajasthan. In case of period-II, the negative growth rate was observed in all aspects viz., area, production and productivity of lentil crop in the state.

**Table 4.2: Compound annual growth rate of area, production and productivity of Lentil in Rajasthan**

(CAGR in Per cent)			
Period	Area	Production	Productivity
Period- I	28.53* (0.028)	40.93* (0.037)	9.40** (0.013)
Period- II	-20.02 (0.061)	-26.72** (0.065)	-8.80** (0.012)
Period- III	38.36* (0.026)	39.96* (0.025)	1.62 (0.012)
Overall	11.94* (0.01)	12.72* (0.012)	0.93 (0.003)

Source: Author's own computed 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 5per cent level of significance

### **Black gram**

Table 4.3 depicted the results of growth rate in area, production and productivity of black gram in Rajasthan. It was indicated from the table that during entire study period, the area, production and productivity of black gram were increased significantly at the rate of 5.20, 8.89 and 3.75 per cent per annum, respectively. The production of black gram may be increased due to positive and significant contribution made by area and productivity of black gram.

In the period-I, the area, of black gram was increased significantly at the rate of 8.89 per cent per annum whereas production and productivity were also increased but non-significantly at the rate of 9.40 and 0.23 per cent per annum, respectively in the state. The production of black gram could be increased due to appreciable rise in area under black gram in period-I.

During period-II, negative and non-significant growth rate was noticed under area (-2.73%) of black gram in Rajasthan. Further, the production and productivity of black gram were augmented at the rate of 4.71 and 7.40 per cent per annum respectively. In this period, productivity may be main contributor to expand the production of black gram. The area might be declined due to drastic expand in area of its competitive crop green gram.

During period-III, the growth rate in all three aspects *viz.*, area, production and productivity of black gram were reported at the rate of 43.22, 62.93 and 14.02 per cent per annum respectively in the state. In the mean time, area and production of black gram were notified remarkable and significant improvements in Rajasthan. Thus it can be concluded from data that area and production of black gram were drastically changed in the period-III during 2008-09 to 2017-2018. At the same time, the production of black gram could be increased due to expand in area and productivity of black gram crop. Bairwa *et al.* (2020), reported a positive growth rate in area, production and productivity of black gram in India during period 1998-2017.

Thus, it could be concluded from the results that area, production and productivity of black gram reported positive and significant growth in entire study period. During period-I, positive and significant growth rate was observed under area of black gram in Rajasthan, while the production and productivity of black gram crop showed positive and non-significant growth rates in the state. In period-II, the production and productivity of black gram were increased non-significantly while area was declined non-significantly in the state. During period-III, the area and production of black gram were reported significant growth rates while productivity was non-significant.

**Table 4.3: Compound annual growth rate of area, production and productivity of Black gram in Rajasthan**

**(CAGR in Per cent)**

<b>Period</b>	<b>Area</b>	<b>Production</b>	<b>Productivity</b>
<b>Period- I</b>	8.89* (0.011)	9.40 (0.032)	0.23 (0.028)
<b>Period- II</b>	-2.73 (0.035)	4.71 (0.051)	7.40 (0.036)
<b>Period- III</b>	43.22* (0.027)	62.93* (0.047)	14.02 (0.036)
<b>Overall</b>	5.20* (0.007)	8.89* (0.011)	3.75** (0.007)

Source: Author's own commutation 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

### **Green gram**

The results of growth rate in area, production and productivity of green gram are presented in Table 4.4. It was revealed from the table that area and production of green gram in Rajasthan were increased significantly at the rate of 13.24 and 19.12 per cent per annum, respectively in the entire study period whereas, the productivity of this crop was increased non significantly at the rate of 5.20 per cent per year. In this period, the production of green gram might be increased due to positive and significant augmentation in area of green gram.

In the period-I (1988-89 to 1997-98), the area under green gram was increased significantly with annual growth rate of 21.34 per cent. In the mean time, the growth rate in production and productivity of green gram were reported at 16.41 and -4.06 per cent per annum, respectively. The production of green gram could be enhanced due to expanded in area under green gram crop only.

During period-II, (1998-99 to 2007-2008) the highest and significant growth rate was found in production (65.20%) of green gram followed by productivity (37.40%) and area (20.50%). In the same period, positive and significant expand in area and productivity of green gram might be major contributor to enhance the production of this crop.

In the period-III, (2008-09 to 2017-2018) the area under green gram in the state was increased significantly at the rate of 15.88 per cent per annum. In case of

production and productivity, the annual growth rate were recorded positive and non-significant with magnitude of 42.89 and 23.31 per cent per year, respectively. In this period, the area and production of green gram might be increased due to remarkable improvement in productivity of green gram crop. Similar results were reported by Mathur and Henry (2005) in area, production and productivity of mung bean in Rajasthan during 1976-2000.

Thus, the study concluded that the area and production of green gram were increased significantly and productivity with non-significantly in the throughout study period. During period-I, area was enhanced significantly and production non-significantly while the productivity was declined non-significantly. In the period-II, area, production and productivity of green gram were reported positive and significantly growth rate in Rajasthan. The area of green gram in period-III showed significant growth rate while production and productivity were non-significantly in the state.

**Table 4.4: Compound annual growth rate of area, production and productivity of Green gram in Rajasthan**  
(CAGR in Per cent)

Period	Area	Production	Productivity
<b>Period- I</b>	21.34* (0.01)	16.41 (0.059)	-4.06 (0.055)
<b>Period- II</b>	20.50* (0.019)	65.20** (0.081)	37.40** (0.068)
<b>Period- III</b>	15.88* (0.022)	42.89 (0.084)	23.31 (0.079)
<b>Overall</b>	13.24* (0.004)	19.12* (0.015)	5.20 (0.014)

Source: Author's own commutation 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

## **Pigeon pea**

The growth rate in area, production and productivity of pigeon pea are presented in the Table 4.5. It was revealed from the table that in the overall period, the area under pigeon pea was declined significantly with annual growth rate of -3.17 per cent in Rajasthan. During same period, the production of pigeon pea was recorded positive and significant growth rate with the magnitude of 0.10 per cent per annum. Further, the productivity of pigeon pea was increase non-significantly at the rate of 3.04 per cent over the year. The small growth in production of pigeon peas was highly attributed by positive growth in productivity of pigeon pea throughout the study period. At the same time, the area registered negative growth; it might be due to positive and significant growth in area of its competitive crop i.e. black gram and green gram.

During period-I, the results stated positive and non significant growth rate in all three aspects *viz.*, area, production and productivity with annual rate of 1.16, 1.86 and 0.69 per cent, respectively. In this period, production of pigeon pea may be increased because of expansion in area and productivity.

The study period-II reported negative and significant growth rate in area of pigeon pea at the rate of -9.43 per cent per annum while the production and productivity of this crop were also showed negative and non-significant growth rate of -10.67 and -0.46 per cent, respectively. In this period, the area under pigeon pea might be declined due to remarkable improvement in area of its competitive crop green gram. The production of pigeon pea could be declined due to negative growth rate in productivity and area of pigeon pea in period-II.

During period-III, the highest and non-significant growth rate was recorded in production (21.90%) followed by area (14.29%) and productivity (6.41) of pigeon pea. This period was characterized positive growth rate in production of pigeon pea; it could be due to appreciable improvement in area and productivity of this crop. Kalmkar (2001) in his study recorded positive and significant growth rate in area, production and productivity of pigeon pea in Maharashtra during 1961-62 to 1997-98.

Thus it could be concluded that production of pigeon pea was slightly increased whereas the area under this crop was declined in overall period. In Rajasthan, the area, production and productivity of pigeon pea were reported positive

growth in period-I and III while in period-II, the performance of pigeon pea was negative in all aspects *viz.*, area, production and productivity of the crop.

**Table 4.5: Compound annual growth rate of area, production and productivity of Pigeon pea in Rajasthan**

(CAGR in Per cent)

Period	Area	Production	Productivity
<b>Period- I</b>	1.16 (0.034)	1.86 (0.0741)	0.69 (0.046)
<b>Period- II</b>	-9.43* (0.012)	-10.67 (0.06)	-0.46 (0.055)
<b>Period- III</b>	14.29 (0.061)	21.90 (0.067)	6.41 (0.31)
<b>Overall</b>	-3.17* (0.08)	0.10* (0.012)	3.04 (0.008)

Source: Author's own commutation 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

#### 4.1.1.2 Growth rates of major pulses in Madhya Pradesh

The compound annual growth rates of area, production and productivity of major pulse crops *viz.*, gram, black gram, green gram, pigeon pea and lentil were unchanged throughout the study period in Madhya Pradesh. Thus, the compound annual growth rates in all aspects *viz.*, area, production and productivity of the pulses were analyzed and presented periodically *viz.*, period-I (1988-89 to 1997-98), period-II (1998-99 to 2007-08) , period-III(2008-09 to 2017-18) and overall (1988-89 to 2017-18) from Table 4.6 to 4.10.

#### Gram

The findings of the growth performance in area, production and productivity of gram are reported in the Table 4.6. It was revealed from table that area, production and productivity of gram in Madhya Pradesh were increased significantly at the rate of 3.04, 6.41 and 3.51 per cent per year, respectively throughout the study period. At the same time, the production of gram could be increased due to positive and significant growth in area and productivity of the crop.

In the period-I, the area, production and productivity under gram was also increased significantly at the rate of 4.95, 12.98 and 7.65 per cent per annum,

respectively. The positive and significant growth in gram production might be characterized due to significant contribution of area and productivity.

In study period-II, the area under gram was increased non-significantly with the rate of 0.69 per cent annually. In the mean time, the production and productivity of gram were recorded negative and non significant growth with the growth rate of -1.37 and -2.05 per cent per annum, respectively in the state. During period, production of gram could be declined due to negative growth rate in productivity.

During period-III (2008-09 to 2017-18), the area, production and productivity of gram in Madhya Pradesh was augmented significantly at the rate of 3.04, 8.14 and 5.20 per cent per annum, respectively. During this period, the production of gram may be increased because of positive and significant improvement in area and productivity of gram. Similar findings were reported by Agrawal *et al.* (2012) in the area, production and productivity of gram in India during period 1970-71 to 2007-08.

The results thus, summarized that area and production of gram in Madhya Pradesh were reported upward and significant growth rate in period-I, III and overall. However, the production and productivity of gram was declined in the period-II.

**Table 4.6: Compound annual growth rate of area, production and productivity of Gram in Madhya Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
<b>Period- I</b>	4.95** (0.007)	12.98* (0.011)	7.65* (0.008)
<b>Period- II</b>	0.69 (0.011)	-1.37 (0.022)	-2.05 (0.015)
<b>Period- III</b>	3.04** (0.006)	8.14** (0.014)	5.20** (0.01)
<b>Overall</b>	3.04* (0.002)	6.41* (0.004)	3.51* (0.002)

Source: Author's own commutation 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

The results of growth performance in area, production and productivity of lentil are reported in the Table 4.7. It could be observed from table that during overall

period, the area, production and productivity of lentil in the Madhya Pradesh were enlarged significantly at the annual rate of 4.47, 7.65 and 3.28 per cent, respectively. In the same period, the growth in lentil production may be due to significant contribution in area and productivity of lentil crop in Madhya Pradesh.

During period-I, Madhya Pradesh recorded significant growth rate in area and production of Lentil at the rate of 12.98 and 13.24 per cent per annum, respectively. However, the productivity of lentil was reported -1.37 per cent per annum significant growth rate in the state. The production of lentil in period-I might be increased due to significant and remarkable improvement in area.

During period-II, the area and production of lentil were significantly declined with -0.46 and -0.07 per cent per annum, respectively whereas productivity recorded 0.23 per cent non-significant growth in the state. The negative growth in lentil area could be accountable for declined production of lentil in period-II. At the same time, area under lentil crop could be declined due to expanded in area of its competitive crop gram.

In the study period-III, state production and productivity of lentil were increased significantly at the rate of 27.35 and 26.47 per cent per annum, respectively whereas area under the crop was increased at the rate of 0.46 per cent annually. The production of lentil in same period was increased in Madhya Pradesh, it might be due to significant and appreciable rise in productivity. Similar findings were reported by Agrwal *et al.* (2012) in the area, production and productivity of lentil in India during period 1970-71 to 2007-08.

Thus, the results summarized that area and production of lentil in Madhya Pradesh were increased in overall period, period-I and period-III, while the area and production of this crop were characterized negative growth rate in period-II. The productivity of lentil was increased in the study periods except period-I.

**Table 4.7: Compound annual growth rate of area, production and productivity of Lentil in Madhya Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	12.98* (0.005)	13.24* (0.008)	-1.37* (0.004)
Period- II	-0.46 (0.007)	-0.07 (0.017)	0.23 (0.011)
Period- III	0.46 (0.007)	27.35* (0.024)	26.47* (0.027)
Overall	4.47* (0.002)	7.65* (0.004)	3.28* (0.005)

Source: Author's own commutation 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

### **Black gram**

Table 4.8 depicted the results of growth rate in area, production and productivity of black gram in Madhya Pradesh. It was indicated in the table that during entire study period, area, production and productivity of black gram were increase significantly at the rate of 4.23, 9.65 and 5.68 per cent per annum, respectively. The state production of black gram was increased might be due to significant expansion in area and productivity of black gram in overall period.

During period-I, the production of black gram was declined but non-significantly at the rate of -3.84 per cent per annum whereas productivity recorded positive and non-significant growth with 2.33 per cent per annum. The area of black gram was recorded negative and significant growth rate -5.81 per cent per annum in the same period. In the mean time, a negative growth in area of black gram could be responsible for reduction in state production of black gram.

During period-II, the production and productivity of black gram were increased at the rate of 5.68 and 4.95 per cent per annum, respectively whereas area under black gram was recorded-2.28 per cent per annum non-significant growth rate in Madhya Pradesh. In this period, production was characterized increasing growth in the state, it could be due to positive growth rate in productivity of black gram. In the

meantime, a remarkable improvement in area of its competitive crop soybean could be accounted for declined in area of black gram in the state.

During period-III, growth rate in area, production and productivity of black gram were observed remarkable significant growth rate of 35.52, 69.04 and 19.95 per cent per annum, respectively in Madhya Pradesh. In this period, the state production of black gram could be augmented due to remarkable and appreciable growth in area and productivity of black gram. Similar findings were reported by Singh and Bansal (2020) in the area, production and productivity of urd beans in Punjab during period 1985-86 to 2017-18.

Thus, it could be summarized from results that during period-III and overall, area, production and productivity of black gram were recorded positive and significant growth rate in Madhya Pradesh. However, area under this crop was declined in period-I and II and production of black gram was increased after period-I in Madhya Pradesh.

**Table 4.8: Compound annual growth rate of area, production and productivity of Black gram in Madhya Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	-5.81* (0.007)	-3.84 (0.014)	2.33 (0.012)
Period- II	-2.28 (0.015)	5.68 (0.024)	4.95 (0.013)
Period- III	35.52* (0.018)	69.04* (0.040)	19.95** (0.024)
Overall	4.23* (0.006)	9.65* (0.010)	5.68* (0.004)

Source: Author's own commutation 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

### Green gram

The estimation of growth rates in area, production and productivity of Green gram in Madhya Pradesh are presented in the Table 4.9. It was revealed from the table that production and productivity of green gram were found positive and significant growth rate with the magnitude of 8.14 and 4.23 per cent per annum in the entire study period. On the other hands, area under green gram was increased non-

significantly with the rate of 3.75 per cent per annum in overall period. In the same time, the growth in production of green gram in Madhya Pradesh might be increased due to positive growth rate in area and productivity of the crop.

In the period-I, area and production of green gram were significantly decreased at the rate of -17.59 and -6.89 per cent, respectively. At the same time, productivity was non-significant increased at the rate of 3.75 per cent annually. In this period, production of green gram was decreased; it could be due to decline in area under green gram crop.

In the period-II, state production of green gram showed negative and non-significant growth rate of -4.28 per cent whereas productivity recorded positive and non significant growth rate 2.80 per cent per annum. In case of area under green gram, it was negative (-6.89%) and significant in the same period. The period-II was also attributed negative growth rate in production, it might be due significant declined in area of green gram in the Madhya Pradesh. At the same time area notified negative and significant growth rate, it might be due to increase in area of its competitive crop as soybean.

During period-III, growth rate in area, production and productivity of green gram were recorded significantly growth at the rate of 62.93, 97.24 and 21.06 per cent, respectively. In this period a remarkable improvement was notified in area and production and productivity of green gram. At the same time, production of green gram was recorded significant and remarkable improvement in Madhya Pradesh, it might be due to appreciable and significant growth in area and productivity of green gram. Similar findings were reported by Singh and Bansal (2020) in the area, production and productivity of Moong bean in Punjab during period 1985-86 to 2017-18.

Thus, it could be summarized from the above analysis that during overall and period-III, area, production and productivity of green gram were observed remarkable and significant growth rate in Madhya Pradesh. However, state area and production of green gram were recorded negative growth rate in period-I and II.

**Table 4.9: Compound annual growth rate of area, production and productivity of Green gram in Madhya Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	-17.59* (0.005)	-6.89** (0.014)	3.75 (0.011)
Period- II	-6.89* (0.006)	-4.28 (0.15)	2.80 (0.011)
Period- III	62.93* (0.039)	97.24* (0.047)	21.06* (0.021)
Overall	3.75 (0.01)	8.14** (0.013)	4.23* (0.004)

Source: Author's own commutation 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

### **Pigeon pea**

The growth in area, production and productivity of pigeon pea are presented in the Table 4.10. It was revealed from the table that area under pigeon pea was significantly increased with rate of 2.57 per cent in overall study period. During same period the production was augmented non-significantly with the magnitude of 1.39 per cent. Subsequently, the productivity of pigeon pea was declined at the rate of -0.92 per cent per annum. The production of pigeon pea in overall period was increased, it could be increased due to positive and significant expand in area.

In the period-I, area, production and productivity of pigeon pea were decreased significantly at the rate of -5.81, -14.89 and -9.22 per cent per annum, respectively in the state. In this period, the production of pigeon pea was declined in Madhya Pradesh, it might be due to negative and significant declined in the area and productivity.

During period-II, area, production and productivity were drastically declined at the rate of -1.83, -6.24 and -4.28 per cent per annum, respectively. It could be observed from the result that production of gram was declined due to reduction in area and productivity of this crop.

During period-III, the area, production and productivity of pigeon pea were increased significantly at the rate of 17.22, 41.58 and 20.78 per cent, respectively in

Madhya Pradesh. During this period, growth in area and productivity in pigeon pea might be accountable for increase in production of pigeon pea in the state. Further, area increased may be due to remarkable improvement in productivity of pigeon pea. Similar results were reported by Ardeshna and Shiyani (2011) in area, production and productivity of pigeon pea in Gujarat during 1960-61 to 2007-08.

The results thus, indicated that during overall and period-III, area and production of pigeon pea were increased over the time in Madhya Pradesh. However, in period-I and II, area and production of this crop were reported negative growth rate. In case of productivity, there was significant increase in growth rate under III period where as decrease pattern were showed in overall period I and II.

**Table 4.10: Compound annual growth rate of area, production and productivity of Pigeon pea in Madhya Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	-5.81* (0.004)	-14.89* (0.015)	-9.22** (0.014)
Period- II	-1.83 (0.009)	-6.24 (0.017)	-4.28 (0.012)
Period- III	17.22* (0.013)	41.58* (0.027)	20.78** (0.035)
Overall	2.57** (0.005)	1.39 (0.008)	-0.92 (0.005)

Source: Author's own commutation 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

#### 4.1.1.3 Growth rates of major pulses in Uttar Pradesh

The compound annual growth rates of area, production and productivity of major pulse crops were not shown definite pattern during entire study periods in Uttar Pradesh. Therefore, the compound annual growth rates in area, production and productivity of selected pulses were computed and presented in the Table 4.11 to 4.15.

## **Gram**

The estimation of growth rates in area, production and productivity of gram in Uttar Pradesh are presented in the Table 4.11. It could be observed from the table that area and production were found negative and significant growth rate in entire study period. The reported growth rate was -7.74 per cent in area followed by -7.32 per cent in production of gram in overall study period. On the other hands, the productivity of chickpea was increased non-significantly with the magnitude of 0.46 per cent in same period. In this period, state production of gram might be decreased due to significant decline in the area of gram in Uttar Pradesh. In the meantime, area under gram could be declined due to expended in area of its competitive crop (wheat).

In the period-I, area and production of gram were decreased significantly at the rate of -10.05 and -9.64 per cent, respectively whereas productivity was increased at the rate of 2.57 per cent annually in Uttar Pradesh. The production of gram was declined in first period; it could be due to decrease in area of this crop.

In the period-II, significant growth rate was seen in area and production at the rate of 11.17 and -13.50 per cent, respectively whereas productivity was declined non-significant with the magnitude of -4.06 per cent. The state production of gram might be declined due to negative growth in productivity of gram crop.

During period-III, the area, production and productivity of gram in the state was declined significantly the rate of -4.94, -6.46 and -0.69 per cent, respectively. The production of gram was declined in third period; it might be due to negative growth in area of this crop. Similar findings were reported by Pichad (2014) in the area, production and productivity of gram in Amravati district of Maharashtra during period 1990-91 to 2009-10.

Thus, it could be concluded from the above analysis that area and production of gram in Uttar Pradesh was declined over the year in all study periods. At the same time, the contribution of productivity was negligible to boost up the production of gram in Uttar Pradesh.

**Table 4.11: Compound annual growth rate of area, production and productivity of Gram in Uttar Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	-10.05* (0.004)	-9.64* (0.010)	2.57 (0.007)
Period- II	11.17* (0.011)	-13.50* (0.018)	-4.06 (0.011)
Period- III	-4.94 (0.028)	-6.46 (0.050)	-0.69 (0.028)
Overall	-7.74* (0.003)	-7.32* (0.006)	0.46 (0.003)

Source: Author's own commutation 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 4.12 depicted the results of growth in area, production and productivity of lentil in Uttar Pradesh. It was indicated in the table that during entire study period, the area, production and productivity of lentil were decreased non-significantly at the rate of -0.46, -0.69 and -0.0026 per cent per annum, respectively. During this period, the production of lentil was declined in Uttar Pradesh; it may be due to negative growth in area and productivity of this crop.

In the first period, area, production and productivity of lentil were also declined non-significantly at the rate of -0.46, -1.09 and -0.69 per cent, respectively in the state.

In the same way, area, production and productivity of lentil were also represented negative and non-significantly growth at the rate of -1.14, -1.37 and -0.23 per cent, respectively in second period.

In case of period-III, the area and production of lentil were declined significantly at -7.10 and -11.08 per cent per annum, respectively in the state. At the same time, productivity under lentil was also decreased non-significantly with -3.84 per cent annually. In the period-I, II and III, the state production of lentil may be decreased due to reduction in area and productivity of lentil in Uttar Pradesh. Acharya

*et al.* (2012) reported similar results in their study for all aspects *viz.*, area, production and productivity of pulses in Karnataka during 1982-83 to 2007-08.

Therefore, it could be summarized from the findings that area, production and productivity of lentil in Uttar Pradesh were declined over the years.

**Table 4.12: Compound annual growth rate of area, production and productivity of Lentil in Uttar Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	-0.46 (0.007)	-1.09 (0.013)	-0.69 (0.007)
Period- II	-1.14 (-0.005)	-1.37 (0.013)	-0.23 (0.012)
Period- III	-7.10** (0.016)	-11.08** (0.027)	-3.84 (0.017)
Overall	-0.46 (0.003)	-0.69 (0.004)	-0.0026 (0.002)

Source: Author's own commutation 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

### **Black gram**

Table 4.13 depicted the results of growth in area, production and productivity of black gram in Uttar Pradesh. It was revealed from the table that during entire study period, area, production and productivity of black gram were significantly increased at the rate of 10.41, 14.82 and 3.75 per cent per annum, respectively. The production of black gram in Uttar Pradesh could be increased due to remarkable contribution in area and productivity of black gram in overall period.

In the period-I, area, production and productivity of black gram was increased significantly at the rate of 6.41, 14.82 and 7.89 per cent, respectively.

In the period-II, area and production of black gram were augmented significantly with 12.72 and 22.46 per cent, respectively whereas productivity was non-significantly increased with 8.64 per cent per annum. During period-I and II, the state production of black gram might be increased due to upward movement in area under black gram crop. In the meantime, an increasing trend was also found in productivity.

During period-III, area under black gram was increased significantly at the rate of 9.65 per cent per annum. The production and productivity of black gram were shown production increased trend by 6.66 and -2.73 per cent, respectively growth rate in the state. At the same time, the production of black gram might be increased due to positive and significant increase by area of black gram crop. Similar results reported by Ahmad *et al.* (2018) in area, production productivity of pulses in eastern India during 2003-16.

Thus, it could be concluded from the results that area, production and productivity of black gram in Uttar Pradesh were increased over the years in all the study periods except productivity in period-III.

**Table 4.13: Compound annual growth rate of area, production and productivity of Black gram in Uttar Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	6.41** (0.010)	14.82* (0.015)	7.89** (0.013)
Period- II	12.72** (0.019)	22.46* (0.025)	8.64 (0.025)
Period- III	9.65** (0.012)	6.66 (0.025)	-2.73 (0.022)
Overall	10.41* (0.003)	14.82* (0.004)	3.75* (0.004)

Source: Author's own commutation 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

### Green gram

Table 4.14 depicted the results of growth performance in area, production and productivity of green gram in Uttar Pradesh. It was indicated in the table that during entire study period, the area, production and productivity of green gram were significantly increased at 13.76, 22.18 and 7.40 per cent per annum, respectively. The production of green gram in overall period might be increased due to appreciable and significant contribution made by area and productivity of green gram crop.

In the period-I, area and production under green gram were significantly increased at 9.40 and 15.61 per cent per annum, respectively whereas the productivity

was non-significant increased at the rate of 5.44 per cent annually. In the same period, the state area and production of green gram might be increased due to positive and remarkable improvement in productivity.

In the second period, area under green gram was increased significantly at 7.89 per cent per annum whereas production and productivity was grown non significantly with the magnitude of 7.65 and 0.93 per cent respectively in the state. During same period, the production of green gram could be increased due to significant contribution in area under green gram.

During third period in the state, the area of green gram was enlarged significantly at 24.74 per cent, respectively whereas the production and productivity were augmented non significant at 0.93 and 7.89 per cent per annum. In Uttar Pradesh, the production of green gram might be increased due to significant contribution of area. Similar results were reported by Mathur and Henry (2005) in area, production and productivity of mung bean in arid district of Rajasthan during 1976-2000.

Thus, it could be summarized from the results that during period-I, II, III and overall, the area, production and productivity of green gram were increased over the year in Uttar Pradesh.

**Table 4.14: Compound annual growth rate of area, production and productivity of Green gram in Uttar Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
<b>Period- I</b>	9.40** (0.012)	15.61** (0.020)	5.44 (0.011)
<b>Period- II</b>	7.89** (0.016)	7.65 (0.034)	0.93 (0.023)
<b>Period- III</b>	24.74** (0.035)	0.93 (0.090)	7.89 (0.023)
<b>Overall</b>	13.76* (0.006)	22.18* (0.010)	7.40* (0.005)

Source: Author's own commutation 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

## **Pigeon pea**

The findings of growth rate in area, production and productivity of pigeon pea are given in the Table 4.15. It could be observed from the table that throughout study period, the area, production and productivity of pigeon pea were significantly decreased at -5.16, -7.96 and -2.95 per cent, respectively in the Uttar Pradesh. In this period the area and production of pigeon pea was declined in Uttar Pradesh, it might be due to negative growth in productivity of pigeonpea. The production of pigeonpea in first period was declined significantly whereas area was non-significantly with the magnitude of -5.81 and -0.23 per cent respectively. On the contrary, productivity of pigeon pea was enhanced significantly at the rate of 5.68 per cent per annum. In this period production of pigeon pea was declined; it may be due to negative growth in area while area of pigeon pea could be declined due to remarkable improvement in area of its competitive crops (black gram and green gram).

In second period, production and productivity of pigeonpea were declined significantly at the rate of -12.70 and -10.46 per cent, respectively while area non-significantly at the rate of -2.50 per cent per annum. The production of pigeon pea was declined in second period; it might be due to both decline in area and productivity.

During period-III in Uttar Pradesh, the area and production of pigeon pea were non-significantly at -2.50 and -0.69 per cent per annum, respectively whereas productivity was augmented non-significantly with 2.57 per cent per annum. The state production of pigeon pea was recorded negative growth rate in third period; it might be due to negative growth in area. Similar findings were reported by Inbasekar (2014) in the area, production and productivity of pigeon pea in India during period 1980-81 to 2006-10. . Similar results reported by Ardeshta and Shiyani (2011) for the Pigeon pea in Gujarat during 1960-61 to 2007-08.

Thus it was evident from the results that area and production of pigeon pea in Uttar Pradesh were declined during the entire study period.

**Table 4.15: Compound annual growth rate of area, production and productivity of Pigeon pea in Uttar Pradesh**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	-0.23 (0.005)	-5.81* (0.006)	5.68** (0.008)
Period- II	-2.50 (0.005)	-12.70* (0.011)	-10.46* (0.011)
Period- III	-2.50 (0.008)	-0.69 (0.032)	2.57 (0.025)
Overall	-5.16* (0.002)	-7.96* (0.004)	-2.95* (0.003)

Source: Author's own commutation 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

#### 4.1.1.4 Growth rates of major pulses in Maharashtra

The compound annual growth rates performance of all aspects *viz.*, area, production and productivity of major pulses *viz.*, chickpea, black gram, green gram, pigeon pea and lentil were changed in all study periods in Maharashtra. Therefore, periodically *viz.*, period-I (1988-89 to 1997-98), period-II (1998-99 to 2007-08) , period-III(2008-09 to 2017-18) and overall (1988-89 to 2017-18) compound annual growth rates in all aspects *viz.*, area, production and productivity of the pulses were analyzed and presented in the Table 4.16 to 4.20.

#### Gram

The findings of growth rate in area, production and productivity of gram were reported in the Table 4.16. It could be observed from the table that during overall period, the area, production and productivity of gram in Maharashtra were increased significantly at the rate of 9.65, 13.76 and 3.75 per cent, respectively. In this period, the area and production of gram were increased in Maharashtra; it might be due to significant increase mode by productivity.

During period-I, affirmative and non-significant growth rate 5.68 and 4.23 per cent were observed in area and production of gram, respectively whereas productivity was declined at the growth rate of -1.37 per cent per annum in Maharashtra. The state

production under gram could be increased due to appreciable growth in area of gram crop.

In second period, the incremental growth rates are area, production and productivity of gram were recorded significant by 12.46, 19.40 and 6.41 per cent per annum, respectively. Gram crop area and production were increased in the state; it could be contributed by remarkable boost up in area and productivity of gram in second period. The expanded area under gram might be accounted by significant growth in gram productivity in Maharashtra.

During the third period, the area under gram was mounted up significantly at 13.76 per cent in the state whereas production and productivity were increased non-significantly at the rate of 14.02 and 0.23 per cent, respectively. The growth in state production of gram might be increase due to remarkable and significant growth in area. Bairwa, *et al.* (2020) also reported similar results in area, production and productivity of chickpea in India during 1998-2017.

Thus, it was concluded from the above analysis that area, production and productivity of gram in Maharashtra were increased in present study periods except productivity of gram in first period.

**Table 4.16: Compound annual growth rate of area, production and productivity of Gram in Maharashtra**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	5.68 (0.017)	4.23 (0.032)	-1.37 (0.020)
Period- II	12.46** (0.020)	19.40** (0.033)	6.41** (0.014)
Period- III	13.76* (0.018)	14.02 (0.033)	0.23 (0.019)
Overall	9.65* (0.003)	13.76* (0.006)	3.75* (0.003)

Source: Author's own commutation 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

The growth in area, production and productivity of lentil are presented in the Table 4.17. It was revealed from the table that during entire study period, area under lentil was decreased significantly at the rate of -5.38 per cent per annum in Maharashtra. The production and productivity of lentil were recorded -3.39 and 0.46 per cent growth rate, respectively in the same period. At the same time, lentil production in Maharashtra was declined; it may be due to negative growth in area of lentil crop and negligible contribution made by productivity of the lentil crop.

During first period, lentil area, production and productivity in the state was augmented non-significantly at 3.75, 7.89 and 0.93 per cent per annum, respectively. In Maharashtra, the lentil production might be increased due to positive growth in area and productivity.

During period-II, area and production of lentil were increased non-significantly with 6.66 and 6.17 per cent, respectively whereas productivity of the crop was noticed -0.23 per cent growth rate in Maharashtra. In second period, production of lentil might be increased due to increase in growth in area of lentil.

During period-III, production and productivity of lentil were enhanced at the rate of 21.62 per cent and 3.99 per cent per annum whereas area under the crop was noticed -2.05 per cent annually growth rate in the state. During this period, production of lentil was also increased in third period; it may be due to positive contribution made by the productivity of lentil. Acharya, *et al.* (2012) in their study reported similar growth pattern in area, production and productivity of pulses in Karnataka during 1982-83 to 2002-03.

Results, thus, concluded that in area and production of lentil were reported negative growth in overall period but in case of period-I and II, area and production were recorded positive growth rate in Maharashtra. The productivity of lentil was showed mixed growth pattern in the state for all study period.

**Table 4.17: Compound annual growth rate of area, production and productivity of Lentil in Maharashtra**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	3.75 (0.040)	7.89 (0.060)	0.93 (0.023)
Period- II	6.66 (0.020)	6.17 (0.056)	-0.23 (0.025)
Period- III	-2.05 (0.047)	21.62 (0.073)	3.99 (0.015)
Overall	-5.38* (0.007)	-3.39 (0.012)	0.46 (0.004)

Source: Author's own commutation 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

### Black gram

Table 4.18 depicted the results of growth in area, production and productivity of black gram in Maharashtra. It was indicated in the table that during entire study period, area under black gram were decreased significantly at the rate of -2.95 and -3.84 per cent, respectively in the state. At the same time, productivity was augmented non-significantly with 1.86 per cent per annum. In this period, production of black gram was decreased because of decline in area of black gram in the state.

In the period-I, positive and non-significant growth rates were seen in production (9.90 per cent) and productivity (2.57 per cent) of the crop whereas area was increased significantly at the rate of 7.15 per cent per annum. During period-I, area and production of black gram were increased in the state because positive growth in productivity.

During period-II, area, production and productivity were declined at the rate of -2.28, -4.50 and -2.28 per cent per annum, respectively. It could be observed from the results that production of black gram was declined due to reduction in the area as well as productivity of the black gram crop.

During period-III, area and production of black gram were declined with the magnitude of -4.28 and -9.01 per cent, respectively. At the same time, productivity of black gram crop reported significant growth at the rate with 15.35 per cent per annum

in the state. In this period production of black gram also declined in Maharashtra, it could be due to decline in area of black gram. Bairwa *et al.* (2020), reported in their study positive growth rate in area, production and productivity of black gram in India during period 1998-2017.

Thus, it could be summarized from the above analysis that area and production of black gram in period-II, III and overall were reported negative growth pattern in Maharashtra. In case of period-I, area, production and productivity of black gram were registered positive growth in the state.

**Table 4.18: Compound annual growth rate of area, production and productivity of Black gram in Maharashtra**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	7.15** (0.010)	9.90 (0.034)	2.57 (0.030)
Period- II	-2.28 (0.010)	-4.50 (0.028)	-2.28 (0.023)
Period- III	-4.28 (0.059)	-9.01 (0.095)	15.35* (0.031)
Overall	-2.95** (0.007)	-3.84* (0.012)	1.86 (0.005)

Source: Author's own commutation 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

### Green gram

The growth in area, production and productivity of green gram are presented in the Table 4.19. It was revealed from this table that during entire study period, area, production and productivity of green gram were declined at the rate of -0.92, -2.28 and -0.69 per cent, respectively in the state. The production of green gram was declined significantly while area and productivity was non-significantly. During same period, area and production of green gram in Maharashtra were reported negative growth pattern; it may be due to negative contribution of black gram productivity.

During period-I, negative and non-significant growth rate was seen in production (-4.76%) and significant growth rate shown in area (-5.16%) of green gram in Maharashtra. The productivity of green gram was increased with 0.69 per

cent per annum in the state. In this period green gram production was also reported negative growth, it might be due to negative growth in area of this crop. In the mean time, area under green gram might be decreased due to significant growth in area of its competitive crop (black gram).

During period-II, area, production and productivity were declined moderately at the rate of -3.62, -5.38 and -2.05 per cent, respectively. During this time production of green gram was declined; it might be due to reduction in area and productivity. In the meantime, area under green gram might be declined due to negative growth in productivity.

During period-III, area, production and productivity were also decline with -3.17, -4.94 and -1.83 per cent, respectively in the state. Similar factors of production were also accountable for reduction in production of green gram in period-III. Mathur and Henry (2005) reported similar results of growth in area, production and productivity of mung bean during 1976-2000.

Thus, it could be concluded from the above analysis that area and production of green gram were declined during period-I, II, III and overall in Maharashtra.

**Table 4.19: Compound annual growth rate of area, production and productivity of Green gram in Maharashtra**

(CAGR in Per cent)			
Period	Area	Production	Productivity
Period- I	-5.16* (0.006)	-4.72 (0.036)	0.69 (0.034)
Period- II	-3.62 (0.011)	-5.38 (0.029)	-2.05 (0.024)
Period- III	-3.17 (0.016)	-4.94 (0.062)	-1.83 (0.050)
Overall	-0.92 (0.002)	-2.28** (0.006)	-0.69 (0.007)

Source: Author's own commutation 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

### Pigeon pea

Table 4.20 depicted the results of growth in area, production and productivity of pigeon pea. It was indicated from the table that during entire study period, area, production and productivity of pigeon pea were increased significantly at the rate of

2.33, 5.44 and 3.04 per cent, respectively. The production of pigeon pea might be increased due to positive and significant contribution made by area and productivity of pigeon pea.

During first Period, area under pigeon pea was reported affirmative and significant growth rate of 2.80 per cent per annum whereas production and productivity were declined with -1.60 and -4.50 per cent, respectively. The production of pigeon pea in period-I was reduced. This may be due to decline in productivity of pigeonpea in the state.

In the period-II, area and production of pigeon pea were significantly increased at 3.04 and 3.51 per cent, respectively whereas productivity was mounted up non-significant at 0.69 per cent annually. In this period production of pigeon pea was significantly increased; it might be due to positive and significant growth in area of pigeon pea.

In the period-III, positive and non-significant growth rate were seen in production (7.65%) and productivity (2.57%) of the crop whereas area was increased significantly at the rate of 4.71 per cent per annum. In the same time production of this crop was increased; it might be due to significant growth in area in the state. At the same time, positive growth in productivity of this crop played a major role to expand in area of pigeon pea. More *et al.* (2015) reported similar findings in area, production and productivity of pigeon pea in Gujarat state during period 1970 to 1980.

Results thus concluded that during throughout study period, area, production and productivity of pigeon pea were recorded positive and significant growth in Maharashtra. During period-I, II and III, area under pigeon pea was significantly increased over the year. The production of pigeon pea was reported positive growth during period-II and III in the state.

**Table 4.20: Compound annual growth rate of area, production and productivity of Pigeon pea in Maharashtra**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	2.80** (0.004)	-1.60 (0.033)	-4.50 (0.033)
Period- II	3.04* (0.003)	3.51** (0.016)	0.69 (0.016)
Period- III	4.71* (0.009)	7.65 (0.032)	2.57 (0.028)
Overall	2.33* (0.001)	5.44* (0.005)	3.04** (0.005)

Source: Author's own commutation 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

#### 4.1.1.5 Growth rates of major pulses in Karnataka

The compound annual growth rates of area, production and productivity of gram, black gram, green gram, pigeon pea and lentil were not remain definite during the entire study period in Karnataka. Thus, the compound annual growth rates in area, production and productivity of selected pulse crops are analyzed periodically and presented in the Table 4.21 to 4.24.

#### Gram

Findings of the growth rate in area, production and productivity of gram were reported in the Table 4.21. It could be observed from this table that throughout study period, the area, production and productivity of gram were significantly increased at 11.17, 18.30 and 4.71 per cent, respectively in the Karnataka. In the same period area and production of gram were significantly increased in Karnataka. At the same time, production might be increased due to positive and significant growth in area and productivity of this crop.

During first period, area, production and productivity of gram were increased significantly at the growth rate of 18.85, 31.52 and 10.66 per cent, respectively. In same period, production of gram might be increased due to remarkable improvement in area and productivity of gram in Karnataka. In the meantime, appreciable growth in productivity was accounted a significant role to expand the area of gram in Karnataka.

During the period-II, area and production under gram were increased significantly at the rate of 15.08 and 11.69 per cent, respectively whereas productivity was declined non-significant with -2.73 per cent in the state. In this period, production of gram was also increased due to positive and significant growth in area of gram in the state.

In the period-III, area, production and productivity of gram were recorded negative and non-significant growth of -7.53, -1.60 and -0.23 per cent, respectively. During this period, negative growth in gram production may be characterized due to negative growth in area and productivity of gram crop in Karnataka. Devraj *et al.* (2014) reported similar findings in area, production and productivity of gram in India during period 1980-81 to 2009-10.

Results of the growth analysis of Karnataka concluded that during overall and period-I, the area, production and productivity of gram were reported significant growth in Karnataka. During period-II area and production of this crop were also recorded significant growth in Karnataka but productivity showed negative and non-significant growth. In the third period, area production and productivity of gram were notified negative growth pattern in the state.

**Table 4.21: Compound annual growth rate of area, production and productivity of Gram in Karnataka**

(CAGR in Per cent)

Period	Area	Production	Productivity
<b>Period- I</b>	18.85* (0.020)	31.52* (0.033)	10.66** (0.019)
<b>Period- II</b>	15.08* (0.016)	11.69** (0.022)	-2.73 (0.021)
<b>Period- III</b>	-7.53 (0.050)	-1.60 (0.052)	-0.23 (0.016)
<b>Overall</b>	11.17* (0.007)	18.30* (0.008)	4.71* (0.004)

Source: Author's own commutation 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

### **Black gram**

Growth rate in area, production and productivity are presented in the Table 4.22. It was revealed from the table that during entire study period, positive and non-

significant growth was found in the area (0.69%) whereas production and productivity reported negative and non-significant growth with -0.69 and -1.37 per cent, respectively in the state. In this period, the production of black gram might be declined due to negative growth in productivity of black gram.

In the period-I, area and production of black gram were increased significantly at the rate of 19.12 and 17.76 per cent, respectively while productivity declined non-significantly at -1.60 per cent per annum in the state. In this time production of black gram was increased; it might be due to remarkable and significant improvement in area of black gram in the state.

In the period-II, area, production and productivity of black gram was declined non-significantly at the rate of -0.46, -14.69 and -14.30 per cent, respectively in the state. In this period, negative growth in area and production of black gram may be reported due to drastic decline in productivity of black gram.

During period-III, production and productivity of black gram were increased non-significantly whereas area was declined with 19.12, 20.23 and -0.92 per cent, respectively in the state. In this period production of black gram was increased in Karnataka; it could be due to remarkable improvement in productivity of black gram in the state. However, area under this crop was declined, it might be due to positive growth in area under its competitive crop (green gram).

Thus, the results of this analysis concluded that throughout the study period, production and productivity of black gram were declined in Karnataka. During period-I, area and production of black gram recorded positive and significant growth but productivity was declined in Karnataka. In second period, area, production and productivity of this crop was declined over the year in Karnataka. The production and productivity of black gram were notified remarkable improvement in period-III with negative growth in the state.

**Table 4.22: Compound annual growth rate of area, production and productivity of Black gram in Karnataka**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	19.12* (0.007)	17.76* (0.054)	-1.60 (0.053)
Period- II	-0.46 (0.015)	-14.69 (0.058)	-14.30 (0.051)
Period- III	-0.92 (0.022)	19.12 (0.054)	20.23 (0.051)
Overall	0.69 (0.005)	-0.69 (0.011)	-1.37 (0.011)

Source: Author's own commutation 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

### Green gram

The growth in area, production and productivity of green gram are presented in the Table 4.23. It was revealed from this table that during overall period affirmative and significant growth rate in area with 3.99 per cent whereas production and productivity were declined with the magnitude of -1.37 and -5.16 per cent, respectively. In this time production of green gram was decreased in Karnataka, it might be due to reduction in productivity of this crop.

During first period, the production and productivity of green gram were declined significantly at -22.73 and -21.66 per cent, respectively whereas area under green gram was also declined non-significantly at the rate of -1.37 per cent in the state. During this period, production of green gram was also declined in Karnataka, it could be due to negative growth in area and productivity of green gram. At the same time area under this crop might be declined due to negative growth in productivity of green gram.

During period-II, positive and non-significant growth rate was noticed in the area (10.15%) of green gram although the production and productivity were decreased non-significantly at the rate of -5.16 and -14.10 per cent, respectively in the state. The production of green gram in period-II was reported negative growth rate; it may be due to remarkable reduction in productivity of this crop.

During third period, the results stated positive and non-significant growth rate in all three aspects viz., area, production and productivity with 6.17, 16.68 and 9.65 per cent, respectively in the state. The affirmative growth in area and productivity of green gram might be major contributor to boost up the production of green gram in the state. In the meantime, area under green gram may be increased due to remarkable improvement in productivity. Mathur and Henry (2005) reported similar results in area, production and productivity of mung bean during 1976-2000.

It can be concluded from above data that production of green gram was declined in period-I, II and overall although in third period production was boost up in the Karnataka. In case of area positive growth rate was notified in period-II, III and overall. The productivity depicted negative growth pattern in period-I, II and overall in the state.

**Table 4.23: Compound annual growth rate of area, production and productivity of Green gram in Karnataka**

**(CAGR in Per cent)**

<b>Period</b>	<b>Area</b>	<b>Production</b>	<b>Productivity</b>
<b>Period- I</b>	-1.37 (0.030)	-22.73** (0.049)	-21.66** (0.034)
<b>Period- II</b>	10.15 (0.026)	-5.16 (0.066)	-14.10 (0.057)
<b>Period- III</b>	6.17 (0.030)	16.68 (0.043)	9.65 (0.039)
<b>Overall</b>	3.99** (0.006)	-1.37 (0.011)	-5.16 (0.009)

Source: Author's own commutation 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

### **Pigeon pea**

Table 4.24 depicted the results of growth in area, production and productivity of Pigeon pea. It was indicated in the Table that during entire study period, area, production and productivity of pigeon pea were significantly increased at the rate of 6.41 per cent, 12.72 per cent and 5.93 per cent per annum respectively. In this period, production of pigeon pea was characterized positive and significant growth; it may be due to positive and significant growth in area and productivity of pigeon pea in

Karnataka. At the same time area under pigeon pea might be increased due to significant contribution made by productivity in pigeon pea.

In the period-I, area and production of pigeon pea were non significantly decreased at the rate of -5.59 and -3.17 per cent, respectively whereas productivity was increased non-significantly at the rate of 3.04 per cent per annum in the overall period. At the same time, production of pigeon pea was declined due to negative growth in area although area under pigeon pea may be declined due to significant and appreciable raise in area of its competitive crop (black gram).

During period-II, performance of growth rate of area and production of pigeon pea were significantly increased at the rate of 7.15 and 16.95 per cent, respectively but productivity was increased non-significantly at the rate of 8.89 per cent annually. Production of pigeon pea was significantly increased, it might be due to positive and significant growth in area of this crop. At the same time, affirmative growth in productivity was also contributed to boost up the production of pigeon pea in Karnataka. During this period, area under pigeon pea may be increased due to positive and appreciable growth in productivity of pigeon pea. In the period-III, area and production under pigeon pea were significantly increased at the rate of 10.15 per cent and 20.23 per cent respectively. At the same time the productivity of this crop was non significant increased at the rate of 8.89 per cent annually. In this period, production was recorded remarkable increase in Karnataka, it might be contributed by positive and significant growth in area. During same period significant growth in area might be contributed with positive growth in area and productivity of pigeonpea. Kalmkar (2001) recorded positive and significant growth rate in area, production and productivity of pigeon pea in Maharashtra during 1961-62 to 1997-98.

Thus it could be summarized from the above analysis that area, production and productivity of pigeon pea in Karnataka were significantly increased in period-II, III and overall. However, in case of period-I, area and productivity were declined in Karnataka.

**Table 4.24: Compound annual growth rate of area, production and productivity of Pigeon pea in Karnataka**

(CAGR in Per cent)

Period	Area	Production	Productivity
Period- I	-5.59 (0.016)	-3.17 (0.036)	3.04 (0.036)
Period- II	7.15* (0.008)	16.95** (0.033)	8.89 (0.028)
Period- III	10.15** (0.021)	20.23** (0.041)	8.89 (0.026)
Overall	6.41* (0.003)	12.72* (0.007)	5.93* (0.005)

Source: Author's own commutation 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

#### **4.1.2 Trend of area, production and productivity of major pulses in selected states of India**

##### **4.1.2.1 Trend of area, production and productivity of major pulses in Rajasthan**

###### **Trend of Gram in Rajasthan:**

In Rajasthan state gram is cultivated in rabi season. All districts of the state are covered under this crop. Based on production, Rajasthan state was holding third position in the country. Linear, quadratic and exponential production functions were fitted to estimate the trend pattern in area, production and productivity of gram in the entire study periods (1988-89 to 2017-18). The R square values for different functions were estimated and only R<sup>2</sup> value of quadratic function was represented in the trend equation of area, production and productivity of gram in the Table 4.25 and figure 4.1. The R square value of quadratic function was higher than linear and exponential function thereby proving the quadratic model was fit to estimate the trend line in area, production and productivity of gram in Rajasthan. In the area, production and productivity of gram, About 22, 74 and 52 per cent of the variation (Coefficient of determination) were explained by the model. During the entire study period, non significant trend was observed in area, production and productivity of gram.

The value of R square in linear, quadratic and exponential function were less than 25 per cent in area of gram in Rajasthan. Therefore trend in area of gram was not explained in the result and discussion.

The estimated trend equation of production depicted that the value of b coefficient (-0.352) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.014) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in production. The quadratic effect was non significant in gram production. Here the quadratic term was also positive implying that production of gram was also increasing over the year.

In case of productivity, the estimated trend equation of productivity observed that the value of b coefficient (-12.697) with time period represented negative linear relation and the value of quadratic (c) coefficient (0.671) with time period, represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of gram. The effect of quadratic (c) coefficient was non significant. Here the quadratic term was positive it means productivity of green gram was increasing over the year. Similar findings were reported by Simhar (2014) in the area, production and productivity of gram in India during period 1980-81 to 2006-07.

**Table 4.25: Estimates of quadratic trend in production and productivity of Gram in Rajasthan of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Production	$Y_t = 10.967 - 0.352t + 0.014t^2$ (0.12)	0.251	0.740
Productivity	$Y_t = 722.043 - 12.697t + 0.671t^2$ (0.345)	0.620	0.520

.Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and\*\*Significant at 5%

Therefore, it could be summarized from the results that during entire study period production and productivity of gram were reported increasing trend over the years in the Rajasthan.

### **Trend in Lentil of Rajasthan:**

Table 4.26 and figure 4.2 presented results of R square values and trend equations of fitted production function for area, production and productivity of lentil in the entire study period (1988-89 to 2017-18). The R square value of quadratic function was higher than linear and exponential function thereby proving the quadratic model was fit to estimate the trend line in area, production and productivity of lentil in Rajasthan. In the area, production and productivity of lentil, about 57, 45 and 19 per cent of the variation (Coefficient of determination) were explained by the model. During the entire study period, significant trend was recorded in all aspects viz., area, production and productivity of lentil.

The estimated trend equation of area depicted that the value of b coefficient (-0.016) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.001) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of lentil was increasing over the year.

At the same time, the estimated trend equation of production revealed that the value of b coefficient (-0.009) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.001) with time period represented the positive quadratic relation. Thus the effect of time period represented the curvature in production. The quadratic (c) coefficient effect was significant in lentil production. Here the quadratic term was also positive implying that production of lentil was also increasing over the year.

The value of R square in linear, quadratic and exponential function were less than 25 per cent in productivity of lentil in Rajasthan. Therefore trend in productivity of lentil was not considered in the result and discussions.

**Table: 4.26 Estimates of quadratic trend in area and production of Lentil in Rajasthan of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 0.225 - 0.016t + 0.001t^{2**}$ (0.371)	0.011	0.565
Production	$Y_t = 0.190 - 0.009t + 0.001t^{2**}$ (0.416)	0.050	0.451

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Therefore, it could be summarized from the results that during entire study period, the quadratic effect was positive in area and production of lentil were reported increasing trend over the year in the Rajasthan.

#### **Trend of Black gram in Rajasthan:**

Black gram is a pioneer pulse crop of Rajasthan. It contributed about 12.25 per cent share in total production of the country. The selected production functions were fitted to work out the trend behaviour in area, production and productivity of black gram in Rajasthan for overall study period. The R square value and estimated trend equations of quadratic function are reported in the Table 4.27 and figure 4.3. It was revealed from the Table that R square value of quadratic function was highest in all aspects viz., area, production and productivity of entire study period. In the area, production and productivity of black gram, about 50, 58 and 35 per cent of the variation (Coefficient of determination) were explained by the quadratic model. During the entire study period, significant trend was observed in area, production and productivity of black gram.

The estimated trend equation of area depicted that the value of b coefficient (-0.153) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.007) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of black gram was increasing over the years.

In the time, the estimated trend equation of production observed that the value of b coefficient (-0.121) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.005) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient was significant in black gram production. Here the quadratic term was also positive implying that production of black gram was also increasing over the year.

In case of productivity, the estimated trend equation of productivity presented that the value of b coefficient (-16.345) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.758) with time period, represented the positive quadratic relation. Thus the effect of time period represented the curvature in the productivity of black gram. The effect of quadratic (c) coefficient was positive and significant. Here the quadratic term was positive it means productivity of black gram was increasing over the year. Similar results were reported by Chandra (2017) in area, production and productivity of groundnut during 1964-65 to 2013-14 period.

**Table: 4.27 Estimates of quadratic trend in area, production and productivity of Black gram in Rajasthan of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> Value
Area	$Y_t = 2.166 - 0.153t + 0.007t^{2*}$ (0.002)	0.002	0.501
Production	$Y_t = 2.166 - 0.121t + 0.005t^{2*}$ (0.001)	0.000315	0.582
Productivity	$Y_t = 413.86 - 16.345t + 0.758t^{2**}$ (0.313)	0.022	0.352

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Therefore, it could be concluded from the findings that during entire study period, the area, production and productivity of black gram were showed increasing trend over the years in the Rajasthan.

### **Trend in Green gram of Rajasthan:**

Green gram is a kharif season crop grown throughout the Rajasthan. It contribute about 51.77 per cent share in total production of the country. Based on production, Rajasthan state is holding first position in India. The selected production functions were fitted to work out the trend behaviour in area, production and productivity of green gram in Rajasthan for entire study periods. The R square value and estimated trend equations were reported in the Table 4.28 and figure 4.4. It was revealed from the Table that R square value of quadratic function was the highest in all aspects *viz.*, area, production and productivity of entire study period. In the area, production and productivity of green gram, about 89, 67 and 25 per cent of the variation (Coefficient of determination) were explained by the quadratic model. During the entire study period, significant trend were observed in area, production and productivity of green gram.

The estimated trend equation of area presented that the value of b coefficient (0.040) with time period represented the positive linear relation and the value of quadratic (c) coefficient (0.011) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of green gram was increasing over the year.

During entire study period, the estimated trend equation of production depicted that the value of b coefficient (-0.130) with time period represented downward linear relation and the value of c (0.011) with time period represented the positive quadratic relation. Thus the effect of time period represented the curvature in production. The quadratic (c) coefficient effect was positive and significant in green gram production. Hence the quadratic term was also positive implying that production of green gram was also increasing over the year.

In case of productivity, the estimated trend equation of productivity observed that the value of b coefficient (-15.993) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.746) with time period represented the positive quadratic relation. Thus the effect of time period represented the curvature in the productivity of green gram. The effect of quadratic (c) coefficient was significant and positive. Here the quadratic term was positive it means productivity of

green gram was increasing over the years. Similar results were reported by Latika *et al.* (2018) in area, production and productivity of total pulses in India during 1950-51 to 2014-15 period.

**Table: 4.28 Estimates of quadratic trend in area, production and productivity of Green gram in Rajasthan of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 3.316 + 0.040t + 0.011t^{2**}$ (0.004)	0.011	0.894
Production	$Y_t = 1.345 - 0.130t + 0.011t^{2*}$ (0.004)	0.009	0.670
Productivity	$Y_t = 331.308 - 15.993t + 0.746t^{2**}$ (0.393)	0.048	0.253

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Thus, the results showed the accelerating trend in area, production and productivity of green gram in Rajasthan throughout the study period.

#### **Trend in pigeon pea of Rajasthan:**

The value of R square in linear, quadratic and exponential function were less than 25 per cent in area, production and productivity of pigeon pea in Rajasthan. Therefore trend in area, production and productivity of pigeon pea was not considered in the result and discussions.

#### **4.1.2.2 Trend of area, production and productivity of major pulses in Madhya Pradesh**

##### **Trend in Gram of Madhya Pradesh:**

Gram is a rabi season crop in the Madhya Pradesh. During 2017-18, Madhya Pradesh was stood first place in production of gram with share of 40.38 per cent. The R square value of quadratic function was higher than linear and exponential function therefore, quadratic model was found best fit to estimate the trend line in area, production and productivity of gram in Madhya Pradesh in Table 4.29 and figure 4.5. It was revealed from the table that area, production and productivity of gram, about 70, 73 and 62 per cent of the variation (Coefficient of determination) were explained by the model. During the entire study period, significant trend was recorded in area and production while non significant trend was observed in productivity of gram.

The estimated trend equation of area revealed that the value of b coefficient (0.010) with time period represented the positive linear relation and the value of quadratic (c) coefficient (0.011) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of gram was increasing over the year in Madhya Pradesh.

At the same time, the estimated trend equation of production depicted that the value of b (0.060) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.024) with time period represented the positive quadratic relation. Thus the effect of time period represented the curvature in production. The quadratic effect was significant in gram production. Here the quadratic term was also positive implying that production of gram was also increasing over the years in Madhya Pradesh.

In case of productivity, the estimated trend equation of productivity presented that the value of b coefficient (5.767) with time period represented positive linear relation and the value of c (0.260) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in the productivity of gram. The effect of quadratic (c) coefficient was significant. Here the quadratic term was positive it means productivity of gram was increasing over the year. Similar findings were reported by Bishat and Kumar (2018) in the area, production and productivity of total pulses in India during period 1996-97 to 2015-16.

**Table: 4.29 Estimates of quadratic trend in area, production and productivity of Gram in Madhya Pradesh of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> Value
Area	$Y_t = 23.295 + 0.010t + 0.011t^{2**}$ (0.006)	0.045	0.697
Production	$Y_t = 18.157 - 0.060t + 0.024t^{2**}$ (0.011)	0.043	0.728
Productivity	$Y_t = 750.442 + 5.767t + 0.260t^2$ (0.272)	0.347	0.621

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and\*\*Significant at 5%

Thus, the results revealed from the table that accelerating trend was notified in area, production and productivity of gram in Madhya Pradesh during throughout the study period.

### **Trend in Lentil of Madhya Pradesh:**

The results of fitted trend equation and R square are given in the Table 4.30 and figure 4.6. It was revealed from the Table that R square value of quadratic function was highest in all aspects *viz.*, area, production and productivity of lentil in entire study period. In the area, production and productivity of lentil, about 84, 68 and 60 per cent of the variation (Coefficient of determination) are explained by the quadratic model. During the entire study period, significant trend were observed in area, production and productivity of black gram.

The estimated trend equation of area observed that the value of b coefficient (0.198) with time period represented the positive linear relation and the value of quadratic (c) coefficient (-0.004) with time period represented the negative quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and negative which was implying that the area of lentil was decreasing over the year in Madhya Pradesh.

At the same time, the estimated trend equation of production revealed that the value of b coefficient (-0.078) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.006) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was significant in lentil production. Here the quadratic term was also positive implying that production of lentil was also increasing over the year.

In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (-30.005) with time period represented downward linear relation and the value of quadratic (c) coefficient (1.275) with time period, represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of lentil. The effect of quadratic (c) coefficient was significant. Hence the quadratic term was positive it means productivity of lentil was increasing over the year. Similar findings was reported by Rathore (2009) in his study

that area, production and productivity of lentil shown an increasing trend during 1991-92 to 2005-06.

**Table: 4.30 Estimates of quadratic trend in area, production and productivity of Lentil in Madhya Pradesh of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> Value
Area	$Y_t = 2.948 + 0.198t - 0.004t^2$ (0.001)	0.001	0.840
Production	$Y_t = 2.081 - 0.078t + 0.006t^2$ (0.002)	0.004	0.676
Productivity	$Y_t = 587.648 - 30.005t + 1.275t^2$ (0.278)	0.000093	0.601

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Therefore, it could be concluded from the above analysis that the effect of time period, represented the curvature in area production and productivity of lentil, the effect of quadratic term were positive and statistically significant in production and productivity while in area quadratic term was negative and significant in Madhya Pradesh during entire study period (1988-89 to 2017-18).

#### **Trend in Black gram of Madhya Pradesh:**

In the Madhya Pradesh, the largest area under black gram was covered in the kharif season. During 2017-18, the Madhya Pradesh state was contributed about 48 per cent in the production of the country. The results of fitted trend equation and R square are given in the Table 4.31 and figure 4.7. It was revealed from the table that R square value of quadratic function was the highest in all aspects viz., area, production and productivity of entire study period. About 68, 65 and 73 per cent of the variation (Coefficient of determination) were explained by the quadratic model in the area, production and productivity of black gram, respectively. During the entire study period, significant trend were observed in area, production and productivity of black gram.

The estimated trend equation of area depicted that the value of b coefficient (-0.666) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.027) with time period represented the positive quadratic

relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of black gram was increasing over the year

At the same time, the estimated trend equation of production presented that the value of b coefficient (-0.492) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.021) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was significant in black gram production. Here the quadratic term was also positive implying that production of black gram was also increasing over the year.

In case of productivity, the estimated trend equation of productivity revealed that the value of b coefficient (-14.038) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.779) with time period, represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of black gram. The effect of quadratic (c) coefficient was significant. Here the quadratic term was positive it means productivity of black gram was increasing over the year. Similar findings were reported by Yahya (2013) in the area, production and productivity of lentil in Andhra Pradesh during 1980-81 to 2010-11 period.

**Table: 4.31 Estimates of quadratic trend in area, production and productivity of Black gram in Madhya Pradesh of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> Value
Area	$Y_t = 8.17 - 0.666t + 0.027t^{2*}$ (0.004)	0.000002	0.677
Production	$Y_t = 3.532 - 0.492t + 0.021t^{2*}$ (0.004)	0.000026	0.651
Productivity	$Y_t = 344.229 - 14.038t + 0.779t^{2*}$ (0.179)	0.00017	0.729

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Thus, from the above analysis, it could be concluded that during entire study period, the trend pattern in area production and productivity of black gram were positive and significant in Madhya Pradesh.

#### **Trend in Green gram of Madhya Pradesh:**

In Madhya Pradesh Green gram grows throughout the year but maximum area was covered in kharif season. During 2017-18, Madhya Pradesh state held second position in total production of India. The results of fitted trend equation and R square are given in the Table 4.32 and figure 4.8. It was revealed from the table that R square value of quadratic function was highest in area, production and productivity of green gram in the entire study period. About 68, 69 and 68 per cent of the variation (Coefficient of determination) are explained by the quadratic model in the area, production and productivity of green gram, respectively. During the entire study period, significant trend were observed in area, production and productivity of green gram.

The estimated trend equation of area observed that the value of b coefficient (-0.261) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.010) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of green gram was increasing over the year.

At the same time, the estimated trend equation of production presented that the value of b coefficient (-0.147) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.006) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was significant in green gram production. Hence the quadratic term was also positive implying that production of green gram was also increasing over the year.

In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (-16.450) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.776) with time period, represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of green gram. The effect of quadratic (c) coefficient

was significant. Here the quadratic term was positive it means productivity of green gram was increasing over the year. Similar findings was reported by Rathore (2009) in his study that area, production and productivity of lentil shown an increasing trend during 1991-92 to 2005-06.

**Table: 4.32 Estimates of quadratic trend in area, production and productivity of Green gram in Madhya Pradesh of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> Value
Area	$Y_t = 2.344 - 0.261t + 0.010t^{2*}$ (0.002)	0.000001	0.676
Production	$Y_t = 0.979 - 0.147t + 0.006t^{2*}$ (0.001)	0.000002	0.693
Productivity	$Y_t = 372.561 - 16.450t + 0.776t^{2*}$ (0.167)	0.000078	0.677

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Based on the above analysis, it could be summarized that during entire study period, the area, production and productivity of green gram was reported positive and significant trend pattern in Madhya Pradesh.

#### **Trend in pigeon pea of Madhya Pradesh:**

The trend analysis of pigeon pea area, production and productivity in Madhya Pradesh was made by fitting quadratic production function. The R square and fitted equation trend analysis are presented in the Table 4.33 and figure 4.9. It was revealed from the table that R square value of quadratic function was recorded highest in area, production and productivity of pigeon pea in the entire study period. In the area, production and productivity of pigeon pea, about 85, 79 and 50 per cent of the variation (Coefficient of determination) were explained by the quadratic model. During entire study period, the significant trend patterns were observed in area, production and productivity of pigeon pea in the state.

The estimated trend equation of area depicted that the value of b coefficient (-0.321) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.012) with time period represented the positive quadratic

relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area pigeon pea was increasing over the year.

At the same time, the estimated trend equation of production revealed that the value of b coefficient (-0.593) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.021) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was significant and positive in pigeon pea production. Here the quadratic term was also positive implying that production of pigeon pea was also increasing over the year.

In case of productivity, the estimated trend equation of productivity presented that the value of b coefficient (-66.117) with time period represented downward linear relation and the value of quadratic (c) coefficient (2.063) with time period represented the positive quadratic relation. Thus the effect of time period represented the curvature in the productivity of pigeon pea. The effect of quadratic (c) coefficient was positive and significant. Here the quadratic term was positive it means productivity of pigeon pea was increasing over the year. Yahaya (2013), in his study worked out that area production and productivity of red gram represented increasing trend pattern in Andhra Pradesh during 1980-1990 period.

**Table: 4.33 Estimates of quadratic trend in area, production and productivity of Pigeon pea in Madhya Pradesh of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 5.306 - 0.321t + 0.012 t^{2*}$ (0.001)	0.001	0.849
Production	$Y_t = 6.251 - 0.593t + 0.021 t^{2*}$ (0.002)	0.001	0.787
Productivity	$Y_t = 1209.662 - 66.117t + 2.063t^{2*}$ (0.401)	0.00021	0.499

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Thus it could be concluded from the above analysis that the effect of time period reported the curvature in area, production and productivity and functional trend

patterns in area, production and productivity of pigeon pea was recorded increasing over the years in Madhya Pradesh during entire study period.

#### **4.1.2.3 Trend of area, production and productivity of major pulses in Uttar Pradesh**

##### **Trend in Gram of Uttar Pradesh:**

The results of trend fitted equation and R square values were depicted in the Table 4.34 and figure 4.10. It was revealed from the Table that R square value of quadratic function was the highest in all aspects viz., area, production and productivity of entire study period. In the area, production and productivity of gram, about 92, 73 and 36 per cent of the variation (Coefficient of determination) are explained by the quadratic model. During the entire study period, significant trend were observed in area and production while non significant trend was observed in productivity of gram.

The estimated trend equation of area revealed that the value of b coefficient (-0.514) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.008) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of gram was increasing over the year in Uttar Pradesh.

At the same time, the estimated trend equation of production observed that the value of b coefficient (-0.406) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.006) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was significant in gram production. Hence the quadratic term was also positive implying that production of gram was also increasing over the year in Uttar Pradesh.

In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (1.762) with time period represented upward linear relation and the value of quadratic (c) coefficient (0.037) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of gram. The effect of quadratic (c) coefficient was non significant. Here the quadratic term was positive it means productivity of gram was

increasing over the year in Uttar Pradesh. Similar findings were reported by Simhar (2014) in the area, production and productivity of gram in India during period 1980-81 to 2006-07

**Table: 4.34 Estimates of quadratic trend in area, production and productivity of Gram in Uttar Pradesh of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 13.572 - 0.514t + 0.008t^{2*}$ (0.002)	0.001	0.924
Production	$Y_t = 11.465 - 0.406t + 0.006t^{2*}$ (0.003)	0.050	0.729
Productivity	$Y_t = 864.739 + 1.762t + 0.037t^2$ (0.009)	0.922	0.360

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Thus, it could be concluded above analysis that area and production of gram were significantly increased in the entire study period.

#### **Trend in Lentil of Uttar Pradesh:**

After Madhya Pradesh, Uttar Pradesh is the prime state with contribution of 24.67 per cent share of total lentil production of country. The results of trend fitted equation and R square values are depicted in the Table 4.35 and figure 4.11. It was revealed from the table that R square value of quadratic function was showed high and positive in all aspects viz., area, production and productivity of entire study period. In the area, production and productivity of lentil, about 41, 30 and 20 per cent of the variation (Coefficient of determination) are explained by the quadratic model. During the entire study period, significant trend were observed in area and production while non-significant in productivity of lentil.

The estimated trend equation of area presented that the value of b coefficient (0.187) with time period represented the positive linear relation and the value of quadratic (c) coefficient (-0.006) with time period represented the negative quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and negative which was implying that the area of lentil was decreasing over the year.

At the same time, the estimated trend equation of production revealed that the value of b coefficient (1.171) with time period represented upward linear relation and the value of quadratic (c) coefficient (-0.006) with time period represented the negative quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was significant in lentil production. Here the quadratic term was also negative implying that production of lentil was also decreasing over the year. Similar results were reported by Chandra (2017) in area, production and productivity of groundnut during 1964-65 to 2013-14 period.

The value of R square in linear, quadratic and exponential function were less than 25 per cent in productivity of lentil in Uttar Pradesh. Therefore trend in production lentil crop was not included in the result and discussion.

**Table: 4.35 Estimates of quadratic trend in area and production of Lentil in Uttar Pradesh of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 4.381 + 0.187t - 0.006t^{2*}$ (0.001)	0.00236	0.406
Production	$Y_t = 3.184 + 1.171t - 0.006t^{2*}$ (0.002)	0.002	0.297

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Thus, from the above findings area and production of lentil showed negative trend in area and production in Uttar Pradesh.

#### **Trend in Black gram of Uttar Pradesh:**

After Madhya Pradesh and Rajasthan states, Uttar Pradesh is prime state with the contribution of 11.45 per cent share of total black gram production of country. The findings of trend fitted equation and R square values are presented in the Table 4.36 and figure 4.12. It was revealed from the table that R square value of exponential function was highest in area and production of black gram in entire study period. In case of productivity, the highest R square value (37) was reported in quadratic function. In the area and production of black gram, about 90 and 87 per cent of the variation (Coefficient of determination) are explained by the exponential model and in the productivity about 37 per cent variation is explained by the quadratic model.

During entire study period, the significant trend pattern was observed in area and production of black gram in Uttar Pradesh.

The b coefficient value (0.043) is exponential in area, meaning curvilinear with increasing in many folds. The effect of exponential (b coefficient) was significant and positive which was implying that the area of black gram was increasing over the year in multiple of times.

At the same time, b coefficient value (0.060) was exponential in black gram production; it means curvilinear with increasing trend. The exponential effect is significant in black gram production. Further, the positive exponential term is implying that black gram production was also mounting over the year.

In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (4.605) with time period represented upward linear relation and the value of quadratic (c) coefficient (0.091) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of black gram. The effect of quadratic (c) coefficient was non significant. Here the quadratic term was positive it means productivity of black gram was increasing over the year. Similar findings were reported by Jhagrawat (2006) in the production of black gram in Rajasthan during 1990-91 to 2004-05.

**Table: 4.36 Estimates of quadratic and exponential trends in area, production and productivity of Black gram in Uttar Pradesh of India Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value	
			Quad.	Expo.
Area	$Y_t = 1.861 \times 0.043^{t^*}$ (0.003)	0.00001	0.892	0.895
Production	$Y_t = 0.618 \times 0.060^{t^*}$ (0.004)	0.00001	0.808	0.871
Productivity	$Y_t = 340.815 + 4.605t + 0.091t^2$ (0.244)	0.712	0.367	0.343

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and\*\*Significant at 5%

Therefore, it could be observed from above analysis that the R square value of exponential function were highest in area and production of black gram reported significant and positive trend behavior in the entire study period wherein productivity, the effect of quadratic (c) term was non-significant in the Uttar Pradesh state.

### **Trend in Green gram of Uttar Pradesh:**

The selected production function i.e. linear, quadratic and exponential function were fitted to work out the trend behaviour in all three aspects *viz.*, area, production and productivity of green gram during entire study period (Table 4.37 and figure 4.13). It was revealed from the table that during entire study period, the R square value of quadratic function was highest in area, production and productivity of green gram in Uttar Pradesh. In the area, production and productivity of green gram, about 85, 81 and 70 per cent of the variation (Coefficient of determination) are explained by the quadratic model. During entire study period, the significant trend pattern was observed in area, production and productivity of green gram.

The estimated trend equation of area revealed that the value of b coefficient (-0.026) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.002) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of green gram was increasing over the year.

At the same time, the estimated trend equation of production presented that the value of b coefficient (-0.020) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.001) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was significant in green gram production. Here the quadratic term was also positive implying that production of green gram was also increasing over the years.

In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (-8.412) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.667) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of green gram. The effect of quadratic (c) coefficient was

significant. Here the quadratic term was positive it means productivity of green gram was increasing over the year. Similar findings were reported by Simhar (2014) in the area, production and productivity of green gram in India during period 1980-81 to 2006-07.

**Table: 4.37 Estimates of quadratic trend in area, production and productivity of Green gram in Uttar Pradesh of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 0.3 - 0.026t + 0.002t^{2*}$ (0.000314)	0.000009	0.850
Production	$Y_t = 0.119 - 0.020t + 0.001t^{2*}$ (0.000244)	0.00003	0.808
Productivity	$Y_t = 280.197 - 8.412t + 0.667t^{2*}$ (0.219)	0.005	0.697

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and\*\*Significant at 5%

Thus the result revealed from above the conclusion that significant accelerating trend was observed in area, production and productivity of green gram in Uttar Pradesh throughout the study period.

#### **Trend of Pigeon pea in Uttar Pradesh:**

Table 4.38 and figure 4.14 presented results of R square value and trend equations of fitted production function for area, production and productivity of pigeon pea in entire study period (1988-89 to 2017-18). The R square value of quadratic production function was higher than linear and exponential model. It was revealed from the table that R square value of quadratic function was highest in area, production and productivity of pigeon pea during entire study period. In the area, production and productivity of black gram, about 89, 84 and 36 per cent of the variation (Coefficient of determination) were explained by the quadratic model. During entire study period, the trend pattern in area, production and productivity of pigeon pea was found non-significant for Uttar Pradesh.

The estimated trend equation of area depicted that the value of b coefficient (-0.099) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.315) with time period represented the positive quadratic

relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was non significant and positive which was implying that the area of pigeon pea was increasing over the years.

At the same time, the estimated trend equation of production observed that the value of b coefficient (-0.201) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.002) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic effect was non significant in pigeon pea production. The quadratic term was also positive implying that production of pigeon pea was also increasing over the years.

In case of productivity, the estimated trend equation of productivity presented that the value of b coefficient (-20.003) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.252) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of pigeon pea. The effect of quadratic (c) coefficient was non significant. Here the quadratic term was positive it means productivity of pigeon pea was increasing over the years. Similar findings were reported by Sharma *et al.* (2013) in the area, production and productivity of pigeon pea in India during period 1980-81 to 2008-09.

**Table: 4.38 Estimates of quadratic trend in area, production and productivity of Pigeon pea in Uttar Pradesh of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 5.444 - 0.099t + 0.0315t^2$ (0.001)	0.704	0.885
Production	$Y_t = 6.639 - 0.201t + 0.002t^2$ (0.001)	0.192	0.844
Productivity	$Y_t = 1249.108 - 20.003t + 0.252t^2$ (0.408)	0.541	0.362

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

From the above analysis it could be concluded that during entire study period, positive and non significant trend behavior was observed in area, production and productivity of pigeon pea in Uttar Pradesh.

#### **4.1.2.4 Trend of area, production and productivity of major pulses in Maharashtra**

##### **Trend in Gram of Maharashtra:**

The trend analysis of gram area, production and productivity in Maharashtra were made by fitting quadratic production function, the R square and fitted equation of trend analysis is presented in the Table 4.39 and figure 4.15. It was revealed from the table that R square value of quadratic function was recorded highest in all aspects *viz.*, area, production and productivity of gram in entire study period (1988-89 to 2017-18). In the area, production and productivity of black gram, about 85, 76 and 51 per cent of the variation (Coefficient of determination) are explained by the quadratic model. During study period, the trend pattern was found significant in area and production of gram while non-significant in the productivity.

The estimated trend equation of area depicted that the value of b coefficient (-0.089) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.016) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of gram was increasing over the year.

At the same time, the estimated trend equation of production revealed that the value of b coefficient (-0.151) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.018) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was significant in gram production. Hence the quadratic term was also positive implying that production of gram was also increasing over the year.

In case of productivity, the estimated trend equation of productivity presented that the value of b coefficient (0.983) with time period represented upward linear relation and the value of quadratic (c) coefficient (0.327) with time period represented the positive quadratic relation. Thus the effect of time period, represented the

curvature in the productivity of gram. The effect of quadratic (c) coefficient was non significant. Here the quadratic term was positive it means productivity of gram was increasing over the year. Similar findings were reported by Jhagrawat (2006) in the production of black gram in Rajasthan during period 1990-91 to 2004-05

**Table: 4.39 Estimates of quadratic trend in area, production and productivity of Gram in Maharashtra of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 6.482 - 0.089t + 0.016t^{2*}$ (0.005)	0.001	0.850
Production	$Y_t = 3.846 - 0.151t + 0.018t^{2*}$ (0.006)	0.006	0.763
Productivity	$Y_t = 541.7 + 0.983t + 0.327t^2$ (0.281)	0.255	0.505

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Thus, it could be concluded from the results that the effect of time period represented in area, production and productivity of gram was observed increasing tendency in Maharashtra during entire study during (1988-89 to 2017-18).

#### **Trend in Lentil of Maharashtra:**

As other parts of India lentil crop is also grown in winter season. The results of R square values and fitted trend equations of selected production functions presented for entire study period in the Table 4.40 and figure 4.16. It was revealed from the table that R square value of quadratic function was found highest in area, production and productivity of lentil during entire study period. In the area, production and productivity of lentil, about 30, 08 and 05 per cent of the variation (Coefficient of determination) are explained by the quadratic model. During entire study period, the area, production and productivity of lentil was showed non-significant trend in Maharashtra.

The estimated trend equation of area revealed that the value of b coefficient (-0.001) with time period represented the negative linear relation and the value of quadratic (c) coefficient (-3.48E-05) with time period represented the negative

quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was non significant and negative which was implying that the area of lentil was decreasing over the year. Similar results were reported by Latika *et al.* (2018) in area, production and productivity of total pulses in India during 1950-51 to 2014-15.

The value of R square in linear, quadratic and exponential function were less than 25 per cent in production and productivity of lentil in Maharashtra. Therefore trend in production and productivity of lentil crop was not included in the result and discussion.

**Table: 4.40 Estimates of quadratic trend in area of Lentil in Maharashtra of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 0.095 - 0.001t - 3.48E-05t^2$ (0.000063)	0.585	0.301

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Thus, it could be concluded from the above inference that positive and non-significant trend behavior were observed in area of lentil in the entire study period.

#### **Trend in Black gram in Maharashtra:**

The results of fitted trend equations and R square values were depicted in the Table 4.41 and figure 4.17. It could be pointed out from the table that R square values of quadratic function was found highest in the area, production and productivity of black gram in Maharashtra during entire study period. In the area, production and productivity of black gram, about 65, 32 and 13 per cent of the variation (Coefficient of determination) are explained by the quadratic model. During the entire study period, the trend pattern in area and production of black gram was observed significant wherein productivity indicated non-significant trend behavior in the state.

The estimated trend equation of area depicted that the value of b coefficient (0.253) with time period represented the positive linear relation and the value of quadratic (c) coefficient (-0.010) with time period represented the negative quadratic relation. Thus, the effect of time period represented the curvature in area. The effect

of quadratic (c) coefficient was significant and negative which was implying that the area of black gram was decreasing over the year.

At the same time, the estimated trend equation of production observed that the value of b coefficient (0.157) with time period represented upward linear relation and the value of quadratic (c) coefficient (-0.006) with time period represented the negative quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was significant in black gram production. Here the quadratic term was also negative implying that production of black gram was also decreasing over the year. Sharma (2015) found in his study that area, production and productivity of Spices shown a decreasing trend during 2002-03 to 2011-12 period.

The value of R square in linear, quadratic and exponential function were less than 25 per cent in productivity of black gram in Maharashtra. Therefore trend in productivity in black gram crop was not included in the result and discussion.

**Table: 4.41 Estimates of quadratic trend in area and production of Black gram in Maharashtra of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 3.732 + 0.253t - 0.010t^2$ (0.002)	0.000003	0.653
Production	$Y_t = 1.639 + 0.157t - 0.006t^2$ (0.002)	0.005	0.321

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Therefore, it could be concluded from the above analysis that during 1988-89 to 2017-18 period, area and production of black gram reported decreasing trend pattern in Maharashtra.

#### **Trend in Green gram of Maharashtra:**

Table 4.42 and figure 4.18 presented results of R square value and trend equations of fitted production function for area, production and productivity of green gram. Based on R square value, the quadratic production function was found best fit rather than linear and exponential model. In the area, production and productivity of

green gram, about 79, 30 and 16 per cent of the variation (Coefficient of determination) were explained by the quadratic model. During the entire study period, significant trend were observed in area wherein non significant trend was observed in production and productivity of green gram.

The estimated trend equation of area presented that the value of b coefficient (-0.035) with time period represented the negative linear relation and the value of quadratic (c) coefficient (-0.003) with time period also represented the negative quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and negative which was implying that the area of green gram was decreasing over the year.

At the same time, the estimated trend equation of production observed that the value of b coefficient (0.026) with time period represented upward linear relation and the value of quadratic (c) coefficient (-0.003) with time period represented the negative quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was non significant in green gram production. Here the quadratic term was also negative implying that production of green gram was also decreasing over the year. Sharma (2015) found in his study that area, production and productivity of Spices shown a decreasing trend during 2002-03 to 201-12.

The value of R square in linear, quadratic and exponential function were less than 25 per cent in productivity of green gram in Maharashtra. Therefore trend in productivity of green gram crop was not included in the result and discussion.

**Table: 4.42 Estimates of quadratic trend in area and production of Green gram in Maharashtra of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 7.623 - 0.035t - 0.003t^2$ (0.002)	0.047	0.790
Production	$Y_t = 3.109 + 0.026t - 0.003t^2$ (0.002)	0.263	0.299

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Thus, the results showed negative and significant trend in area of green gram during entire study period, while production reported negative and non-significant trend pattern under green gram in Maharashtra.

### **Trend in Pigeon pea of Maharashtra:**

During 2017-18, the Maharashtra state was contributed about 25 per cent share in the total pigeon pea production of the country. The Maharashtra state was also remained position in the production of pigeon in the country. Linear, quadratic and exponential production function were used to estimate the trend equations. The trend equations and R square values for area, production and productivity of pigeon pea were presented in the Table 4.43 and 4.19. It was revealed from the table that R square value of quadratic function was recorded highest in all aspects *viz.*, area, production and productivity of pigeon pea, about 72, 43 and 22 per cent of the variation (Coefficient of determination) were explained by the quadratic model. During entire study period, the area of pigeon pea was showed significant trend pattern where in production and productivity of pigeon pea it was non-significant in the Maharashtra.

The estimated trend equation of area presented that the value of b coefficient (0.015) with time period represented the positive linear relation and the value of quadratic (c) coefficient (0.003) with time period also represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of pigeon pea was increasing over the year.

At the same time, the estimated trend equation of production observed that the value of b coefficient (0.094) with time period represented upward linear relation and the value of quadratic (c) coefficient (0.003) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic effect was non significant in pigeon pea production. Hence the quadratic term was also positive implying that production of pigeon pea was also increasing over the year. Similar results were reported by Latika *et al.* (2018) in the area, production and productivity of total pulses in India during 1950-51 to 2014-15.

The value of R square in linear, quadratic and exponential function were less than 25 per cent in productivity of pigeon pea in Maharashtra. Therefore trend in productivity in pigeon pea crop was not included in the result and discussion.

**Table: 4.43 Estimates of quadratic trend in area and production of Pigeon pea in Maharashtra of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 9.813 + 0.015t + 0.003t^{2*}$ (0.002)	0.093	0.719
Production	$Y_t = 5.319 + 0.094t + 0.003t^2$ (0.005)	0.609	0.432

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Therefore, it could be concluded from the above analysis that, the effect of time period represented the curvature in area. The effect of quadratic (c) was significant and positive which was implying that the area of pigeon pea was increasing over the years while the quadratic effect was non significant in pigeon pea production. Hence the quadratic term was also positive implying that production of pigeon pea was also increasing over the years during entire study period (1988-89 to 2017-18 in the Maharashtra.

#### **4.1.2.5 Trend of area, production and productivity of major pulses in Karnataka**

##### **Trend in Gram of Karnataka:**

Throughout in the Karnataka, gram is cultivated in winter season. The linear, exponential and quadratic production function were fitted to compute the trend pattern in area, production and productivity of gram in selected study period (1988-89 to 2017-18). Based on the highest R square values of production function best-fit model were used to compute the trend equation in area, production and productivity of gram in Karnataka. The trend equation of best fit model and R square value of different production function were presented in the Table 4.44 and 4.20. It was revealed from the table that R square value of exponential function was recorded highest in the area and production of gram in entire study period. In case of productivity, the highest R square value was 56 per cent reported in quadratic function. In the area and production of gram, about 63 and 77 per cent of the variation (Coefficient of

determination) were explained by the exponential model and in the productivity about 56 per cent variation was explained by the quadratic model. Throughout the study period, the area and production of gram was showed significant trend behaviour while in the productivity it was non-significant in the Karnataka.

In the model, the b coefficient value (0.046) was exponential in area, showing curvilinear with increasing trend in many folds. The effect of exponential (b coefficient) term was positive and significant which was implying that the area of gram was increasing over the year in multiple of times in the state.

At the same time, in the best-fit model, the b coefficient value (0.073) was exponential in gram production; it means curvilinear with increasing trend. The exponential effect in the production of gram was significant and the exponential term was also positive, it means production of gram was also increasing over the year in Karnataka.

In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (21.715) with time period represented upward linear relation and the value of quadratic (c) coefficient (-0.383) with time period represented the negative quadratic relation. Thus the effect of time period, represented the curvature in the productivity of gram. The effect of quadratic (c) coefficient was non significant. Here the quadratic term was negative it means productivity of gram was decreasing over the year. Similar findings were reported by Avinash and Patil (2018) in the area, production and productivity of major pulses in Karnataka during 1980 to 2016 period.

**Table: 4.44 Estimates of quadratic and exponential trends in area, production and productivity of Gram in Karnataka of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value	
			Quad.	Expo.
Area	$Y_t = 2.136 \times 0.046^{t*}$ (0.007)	0	0.526	0.633
Production	$Y_t = 0.736 \times 0.073^{t*}$ (0.008)	0	0.686	0.768
Productivity	$Y_t = 303.374 + 21.715t - 0.383t^2$ (0.228)	0.105	0.557	0.505

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Therefore, it could be observed from the above analysis that during entire study period, the area and production of gram was showed significant and positive trend behaviour while in productivity it was non-significant in the Karnataka.

#### **Trend in Black gram of Karnataka:**

Black gram cultivated in summer season in Karnataka like rest part of the country. The R square value of linear, quadratic exponential production function and selected trend equation were presented in the Table 4.45 and 4.21. It was revealed from the table that R square value of quadratic function was recorded highest in all aspects *viz.*, area, production and productivity of black gram during the study period (1988-89 to 2017-18). In the area, production and productivity of black gram, about 46, 05 and 09 per cent of the variation (Coefficient of determination) are explained by the quadratic model. Throughout the study period, area of black gram showed significant trend pattern where in case of production and productivity it was non-significant found in the state.

The estimated trend equation of area showed that the value of b coefficient (0.077) with time period represented the positive linear relation and the value of quadratic (c) coefficient (-0.002) with time period represented the negative quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and negative which was implying that the area of black gram was decreasing over the year. Sharma (2015) found in his study that area and production of Spices shown an decreasing trend during 2002-03 to 2011-12.

The value of R square in linear, quadratic and exponential function were less than 25 per cent in production and productivity of black gram in Karnataka. Therefore trend in production and productivity of black gram crop was not included in the result and discussion.

**Table: 4.45 Estimates of quadratic trend in area of Black gram in Karnataka of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 0.683 + 0.077t - 0.002t^2$ (0.001)	0.000053	0.464

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Therefore, it could be concluded from the analysis the negative and significant trend pattern was reported in area under black gram of Karnataka in the entire study period (1988-89 to 2017-18).

### **Trend in Green gram of Karnataka:**

The trend analysis in area, production and productivity of Green gram were computed and shown in the Table 4.46 and figure 4.22 for the study period 1988-89 to 2017-18. It was revealed from the table that R square value of quadratic function was recorded highest in area, production and productivity of green gram in the study period. In the area, production and productivity of black gram, about 27, 06 and 44 per cent of the variation (coefficient of determination) are explained by the quadratic model. During overall study period, the productivity of green gram reported significant trend pattern while area and production non-significant in the state.

At the same time, the estimated trend equation of production presented that the value of b coefficient (-0.042) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.001) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in production. The quadratic (c) coefficient effect was non-significant in green gram production. Here the quadratic term was also positive implying that production of green gram was also increasing over the year.

The value of R square in linear, quadratic and exponential function were less than 25 per cent in production of green gram in Karnataka. Therefore trend in production green gram crop was not included in the result and discussion.

In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (-28.920) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.718) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of green gram. The effect of quadratic (c) coefficient was significant. Here the quadratic term was positive it means productivity of green gram was increasing over the year. Similar findings were reported by Avinash and Patil (2018) in the area, production and productivity of major pulses in Karnataka during period 1980 to 2016.

**Table: 4.46 Estimates of quadratic trend in area and productivity of Green gram in Karnataka of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 1.699 + 0.178t - 0.004t^2$ (0.002)	0.101	0.267
Productivity	$Y_t = 476.699 - 28.920t + 0.718t^2$ (0.245)	0.007	0.436

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Therefore, it could be summarized from the analysis that positive and significant trend pattern was reported in the productivity. Subsequently, positive but non significant trend was reported negative and non-significant trend in green gram in Karnataka during the study period (1988-89 to 2017-18).

#### **Trend in pigeon pea of Karnataka:**

The results of fitted trend equations and R square value of linear, quadratic and exponential function were presented in the Table 4.47 and figure 4.23. It was observed from the table that quadratic function was best fit to estimate the trend line in area production and productivity of pigeon pea in entire study period. In the area, production and productivity of pigeon pea, about 74, 67 and 47 per cent of the variation (Coefficient of determination) are explained by the quadratic model. During the study period, significant trend was observed in area and production of pigeon pea while non-significant in the productivity.

The estimated trend equation of area revealed that the value of b coefficient (-0.098) with time period represented the negative linear relation and the value of quadratic (c) coefficient (0.009) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which was implying that the area of pigeon pea was increasing over the year.

At the same time, the estimated trend equation of production showed that the value of b coefficient (-0.072) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.008) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in

production. The quadratic effect was significant in pigeon pea production. Here the quadratic term was also positive implying that production of pigeon pea was also increasing over the year.

In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (8.105) with time period represented upward linear relation and the value of quadratic (c) coefficient (0.126) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of pigeon pea. The effect of quadratic (c) coefficient was non significant. Here the quadratic term was positive it means productivity of pigeon pea was increasing over the year. Similar results were reported by Latika *et al.* (2018) in area, production and productivity of total pulses in India during 1950-51 to 2014-15.

**Table: 4.47 Estimates of quadratic trend in area, production and productivity of Pigeon pea in Karnataka of India (Period: 1988-89 to 2017-18)**

Aspects	Estimated trend equation	P value	R <sup>2</sup> value
Area	$Y_t = 4.696 - 0.098t + 0.009t^{2*}$ (0.003)	0.003	0.743
Production	$Y_t = 1.771 - 0.072t + 0.008t^{2**}$ (0.003)	0.020	0.668
Productivity	$Y_t = 321.992 + 8.105t + 0.126t^2$ (0.032)	0.696	0.469

Note: Figures in parenthesis are standard error of regression coefficient

\*Significant at 1%, and \*\*Significant at 5%

Thus, it was concluded from the above analysis that upward and significant trend pattern was observed in area and production of pigeon pea while positive and non significant trend was recorded of pigeon pea in Karnataka during the study period (1988-89 to 2017-18).

#### 4.2 Decomposition of production growth for individual crop:

The previous section presented the growth and trend in area, production and productivity of major pulses in major states. An analysis of growth in area, production and productivity of selected pulses viz., Gram, Lentil, Black gram, Green gram, Pigeon pea and Lentil were indicated mixed trend pattern and the direction of

alteration in area and productivity. But this does not explain the share of area and productivity to the growth in production. For this it is mandatory to compute the factors of production growth. The growth in output of selected pulse crops were therefore allocated to the various factors by breaking the change in output into three effects *viz.*, yield effect, area effect and interaction effect. An effort was made to study how far the relative contribution of yield, area and their interaction was instrumental for the increase in production of selected crops through decomposition analysis. The results are presented and discussed in the following section.

#### **4.2.1 Sources of output growth in Rajasthan:**

##### **Gram:**

The relative contribution of yield, area and their interaction to change in production of gram in Rajasthan are presented in the Table 4.48 and figure 4.24. It could be seen from the table that during overall period, all three variables were responsible for the growth in gram production. During entire period, growth in production was mainly achieved due to interaction effect (43.88%) followed by yield effect (30.62%) and area effect (25.50%).

During period-I, highest contribution was made by area effect (68.62%) followed by yield effect (19.04 per cent) and interaction effect (12.34 per cent) to boost up the gram production. During period-II, area effect was more dominant than yield and interaction effect. In this period the output of gram was increased by 75.88 per cent due to expansion of area and 19.77 per cent 4.35 per cent due to increased yield and rest of growth by interaction effect. During period-III, interaction effect accounted 48.87 per cent of the total output growth while contribution of yield effect was 30.62 per cent and the area effect to extent 14.83 per cent. Similar findings were reported by More *et al.* (2015) in area effect, yield effect and their interaction effect of gram in Gujarat state during 1960-61 to 2010-11

**Table 4.48: Per cent contribution of area, yield and their interaction on production of Gram in Rajasthan (1988-89 to 2017-18)**

(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	68.62	19.04	12.34
<b>Period- II</b> (1998-99 to 2007-08)	75.88	19.77	4.35
<b>Period- III</b> (2008-09 to 2017-18)	14.83	36.30	48.87
<b>Overall</b> (1988-89 to 2017-18)	25.50	30.62	43.88

Source: Author's own commutation from compiled time series data.

Thus it could be summarized from the above analysis that area effect was prime contributor in period-I and II but in case of period-III and overall interaction effect was major contributor to increase the production of gram in Rajasthan.

#### **Lentil:**

Results of decomposition of growth of lentil output is presented in the Table 4.49 and figure 4.25. During entire study period, area effect accounted 79.59 per cent of the total output growth while contribution of yield effect was 20.23 per cent and the interaction effect with magnitude 0.19 per cent.

During period-I, area expansion was comparatively more instrumental in increasing in production of lentil while yield effect and its interaction effect were next in order with 27.85 per cent and 14.87 per cent contribution to the output growth of lentil. Area effect accounted 57.28 per cent of the output growth. During period-II, area effect and yield effect were mainly responsible for the output growth of lentil accounting for 94.15 and 13.32 per cent of the total output growth of lentil in Rajasthan while interaction effects on production was negative accounting -7.47 per cent. During period-III, the area effect and yield effect were the force of output growth with 87.03 and 22.23 per cent contribution respectively, while negative interaction effect (9.26) had encountered by area and yield effect. Similar findings were reported More et al. (2015) in area effect, yield effect and their interaction effect of lentil in Gujarat state during 1960-61 to 2010-11

**Table 4.49: Per cent contribution of area, yield and their interaction on production of Lentil in Rajasthan (1988-89 to 2017-18)**

(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	57.28	27.85	14.87
<b>Period- II</b> (1998-99 to 2007-08)	94.15	13.32	-7.47
<b>Period- III</b> (2008-09 to 2017-18)	87.03	22.23	-9.26
<b>Overall</b> (1988-89 to 2017-18)	79.58	20.23	0.19

Source: Author's own commutation from compiled time series data.

It is thus observed from the above table that area effect was mainly responsible for increase in production of lentil in the Rajasthan.

#### **Black gram:**

Decomposition of output growth into its constituent forces for black gram is presented in the Table 4.50 and figure 4.26. It was revealed from the this table that during overall period area expansion was comparatively more instrumental in increasing in production of black gram while yield effect and its interaction effect were next in order with 12.63 per cent and 9.36 per cent contribution to the output growth of black gram. Area accounted for 78.01 per cent of the output growth. During period-I, area effect was mainly responsible for the output growth of black gram accounting for 102.69 per cent and yield effect had very small contribution to extent of 2.65 per cent of the total output growth of black gram in Rajasthan while interaction effects on production was negative accounting -5.34 per cent. During period-II, increase in production of black gram was mainly due to yield effect and interaction effect with 158.70 per cent and 45.83 per cent contribution respectively while area effect was negative on production of black gram with -104.53 per cent contribution. During period-III, the contribution of area effect was higher than yield effect and interaction effect in accelerating the output of black gram. The output of black gram increased by 75.52 per cent, 21.25 per cent and 3.23 per cent due to expansion of area, yield and their interaction. More et al. (2015) in area effect, yield effect and their interaction effect of black gram in Gujarat state during 1960-61 to 2010-11

**Table 4.50: Per cent contribution of area, yield and their interaction on production of Black gram in Rajasthan (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	102.69	2.65	-5.34
<b>Period- II</b> (1998-99 to 2007-08)	-140.53	158.70	45.83
<b>Period- III</b> (2008-09 to 2017-18)	75.52	21.25	3.23
<b>Overall</b> (1988-89 to 2017-18)	78.01	12.63	9.36

Source: Author's own commutation from compiled time series data.

The break - up of the increase in black gram production into its components revealed that area was the major factor in increasing production in the state except period-II. During period-II, yield effect was more dominant than area and their interaction to produce the black gram in Rajasthan.

#### **Green gram:**

The relative contribution of yield, area and their interaction to change in production of gram in Rajasthan are presented in the Table 4.51 and figure 4.27. It could be seen from the table that during overall period, the growth in production of green gram was mainly achieved through interaction and area effect. The contribution of interaction and yield effect in the production growth in this period was about 70.26 per cent and 64.99 per cent, respectively. The yield effect was however negative being -35.25 per cent.

During period-I, area effect and interaction effect played a major role in increasing production of green gram with 198.69 per cent and 92.58 per cent. During period-II, interaction effect turned out to be most powerful factor in the growth of green gram crop with 76.85 per cent. The area effect and yield effect were small with magnitude of 17.67 per cent and 5.48 per cent respectively. During period-III, area effect and interaction effect played a major role in increasing production of green gram with 91.50 per cent and 31.12 per cent respectively. Latika *et al.* (2015) in area effect, yield effect and their interaction effect of total pulses in India during 1950-51 to 2014-15

**Table 4.51: Per cent contribution of area, yield and their interaction on production of Green gram in Rajasthan (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	198.69	-191.27	92.58
<b>Period- II</b> (1998-99 to 2007-08)	17.67	5.48	76.85
<b>Period- III</b> (2008-09 to 2017-18)	91.50	-22.62	31.12
<b>Overall</b> (1988-89 to 2017-18)	64.99	-35.25	70.26

Source: Author's own commutation from compiled time series data.

Thus it could be summarized from the above analysis that area effect was prime contributor in period-I and III but in case of period-II and overall interaction effect was major contributor to increase the production of green gram in Rajasthan.

#### **Pigeon pea:**

The Table 4.52 and figure 4.28 represented the contribution of area, productivity and their interaction to the output growth of pigeon pea in Rajasthan sate. It was observed from this table that during overall period, however interaction effect turned out to be the most powerful factor in growth of pigeon pea with 100.66 per cent. Area and yield effect were very small during this time with -0.77 and 0.11 per cent, respectively.

During period-I, increase in production of pigeon pea was mainly due to interaction effect with 99.96 per cent while yield effect was very small 0.13 per cent contribution. Area effect was negative on production of pigeon pea with -0.09 per cent. During period-II, yield effect was more dominant than the area effect and interaction effect to produce the output. In this period productivity and area influenced the production of pigeon pea crop during period-II to a large extent with its contribution as 92.88 per cent and 25.19 per cent to the output growth respectively. The interaction effect however had negative contribution to the production with -18.07 per cent. During period-III, area effect was mainly responsible for the output growth of pigeon pea accounting for 163.03 per cent of the total output growth while yield effect and interaction effect had negative effect on production with -10.34 and -

52.69 per cent, respectively. Similar findings observed by More et al. (2015) in area effect, yield effect and their interaction effect of pigeon pea in Gujarat state during 1960-61 to 2010-11

**Table 4.52: Per cent contribution of area, yield and their interaction on production of Pigeon pea in Rajasthan (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	-0.09	0.13	99.96
<b>Period- II</b> (1998-99 to 2007-08)	25.19	92.88	-18.07
<b>Period- III</b> (2008-09 to 2017-18)	163.03	-10.34	-52.69
<b>Overall</b> (1988-89 to 2017-18)	0.77	0.11	100.66

Source: Author's own commutation from compiled time series data.

Thus it could be summarized from the above analysis that interaction effect was prime contributor in period-I and overall period. During period-II, yield effect was more dominant but in case of period-III, area effect was major contributor to increase the production of pigeon pea in Rajasthan.

#### **4.2.2 Sources of output growth in Madhya Pradesh:**

##### **Gram:**

The relative contribution of yield, area and their interaction to change in production of gram in Madhya Pradesh are presented in the Table 4.53 and figure 4.29. It could be seen from the table that during overall period, the growth in production of gram was mainly achieved through interaction effect. The contribution of interaction effect in the production growth in this period was about 97.95 per cent respectively. The yield effect and area effect were negligible with 1.17 per cent and 0.88 per cent.

During period-I, yield effect and area effect played a major role in increasing production of green gram with 64.90 per cent and 31.32 per cent. During period-II, interaction effect turned out to be most powerful factor in the growth of green gram crop with 99.87 per cent. The area effect and yield effect were very small with magnitude of 0.08 per cent and 0.05 per cent respectively. During period-III,

interaction effect played a major role in increasing production of green gram with 99.77 per cent. The area effect and yield effect were very small with magnitude of 0.11 per cent and 0.12 per cent respectively. Similar results were reported by Sandeep *et al.* (2016) in area effect, yield effect and their interaction effect of Chickpea in western Vidarbha during 1983-84 to 2012-13.

**Table 4.53: Per cent contribution of area, yield and their interaction on production of Gram in Madhya Pradesh (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	31.32	64.90	3.78
<b>Period- II</b> (1998-99 to 2007-08)	0.05	0.08	99.87
<b>Period- III</b> (2008-09 to 2017-18)	0.11	0.12	99.77
<b>Overall</b> (1988-89 to 2017-18)	0.88	1.17	97.95

Source: Author's own commutation from compiled time series data.

Thus it could be analyzed from the above table that interaction effect were prime contributor in period-II,III and overall but in case of period-I yield effect was major contributor to increase the production of gram in Madhya Pradesh.

#### **Lentil:**

Results of decomposition of growth of lentil output is presented in the Table 4.54 and figure 4.30 .It was revealed from the table that during overall period, yield effect was more dominant than area and interaction effect. In this period the output of lentil was increased by 70.90 per cent due to expansion of yield while 28.24 and 0.86 per cent due to increased area and rest of growth by interaction effect.

During period-I, change in production was mainly due to its area effect and interaction effect. The yield effect however had negative bearing on production. The area and interaction effect contributed as 135.78 and 9.15 per cent of total production growth while yield effect had negative contribution to the extent of -44.93 per cent. During period-II, the area effect turned out to the most powerful factor in the growth of lentil in Rajasthan with 98.62 per cent. Yield and interaction effect were very small during this period with 0.42 and 0.96 per cent respectively. During period-III, increase

in production of lentil in Madhya Pradesh was mainly due to its productivity growth. The area had positive bearing on production and interaction effect negative bearing on production of lentil in Madhya Pradesh. The yield effect contributed as high 88.77 per cent of total production while area effect had positive contribution and interaction element had negative contribution to the extent of 12.19 and -0.96 per cent, respectively. More et al. (2015) in area effect, yield effect and their interaction effect of gram in Gujarat state during 1960-61 to 2010-11

**Table 4.54: Per cent contribution of area, yield and their interaction on production of Lentil in Madhya Pradesh (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	135.78	-44.93	9.15
<b>Period- II</b> (1998-99 to 2007-08)	98.62	0.42	0.96
<b>Period- III</b> (2008-09 to 2017-18)	12.19	88.77	-0.96
<b>Overall</b> (1988-89 to 2017-18)	28.24	70.90	0.86

Source: Author's own commutation from compiled time series data.

Thus it could be summarized from the above analysis that area effect was prime contributor in period-I and II but in case of period-III and overall yield effect was major contributor to increase the production of lentil in Madhya Pradesh.

#### **Black gram:**

Results depicted in the Table 4.55 and figure 4.31 revealed that, during overall period, change in production of black gram was mainly due to area for Madhya Pradesh state as a whole. The yield and interaction effect had positive bearing on output. The area effect contributed as high 58.61 per cent while yield and interaction variables had positive contribution to the extent of 26.52 and 14.87 per cent, respectively.

The growth in production of black gram during period-I was mainly achieved through area alone, while yield and interaction effect had negative effect on change of production. The area effect contributed as high 515.35 per cent while yield and interaction variables had negative contribution to the extent of -388.42 and -29.93 per

cent, respectively. The growth in production of black gram during period-II was mainly achieved through area alone, while yield and interaction effect had positive effect on change of production. The area effect contributed as high 360.11 per cent while yield and interaction variables had negative contribution to the extent of -87.41 and -172.70 per cent, respectively. During period-III change in production of black gram was mainly due to area for Madhya Pradesh state as a whole. The yield and interaction effect had positive bearing on output. The area effect contributed as high as 62.87 per cent while yield and interaction variables had positive contribution to the extent of 23.83 and 13.30 per cent, respectively. Similar analysis reported by Kumar and Shekhar (2017) in area effect, yield effect and their interaction effect of wheat in India state during 1950-51 to 2015-16.

**Table 4.55: Per cent contribution of area, yield and their interaction on production of Black gram in Madhya Pradesh (1988-89 to 2017-18) (In Per cent)**

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	515.35	-388.42	-29.93
<b>Period- II (1998-99 to 2007-08)</b>	360.11	-87.41	-172.70
<b>Period- III (2008-09 to 2017-18)</b>	62.87	23.83	13.30
<b>Overall (1988-89 to 2017-18)</b>	58.61	26.52	14.87

Source: Author's own commutation from compiled time series data.

It is thus observed from the above table that area effect was mainly responsible for increase in production of black gram in the Madhya Pradesh.

#### **Green gram:**

Results of decomposition of growth of lentil output is presented in the Table 4.56 and figure 4.32 .It was revealed from the table that during overall period, yield effect was more responsible than area and interaction effect. In this period the output of green gram was increased by 69.28 per cent due to expansion of yield while 25.89 and 4.83 per cent due to increased area and rest of growth by interaction effect.

The growth in production of green gram during period-I was mainly achieved through area and productivity expansion. The contribution of area in the production

growth in this period was 99.60 per cent. The yield effect was positive (11.34%) and interaction effect was negative (-10.94%). During period-II the change in production was due to area (102.01%) and yield effect (8.76%) while interaction effect observed negative (-10.77%). During period-III, yield effect was more dominant than area and interaction effect. In this period the output of green gram was increased by 60.69 per cent due to expansion of yield while 36.69 and 2.62 per cent due to increased area and rest of growth by interaction effect. Similar results were reported by Sandeep *et al.* (2016) in area effect, yield effect and their interaction effect of Green gram in western Vidarbha during 1983-84 to 2012-13.

**Table 4.56: Per cent contribution of area, yield and their interaction on production of Green gram in Madhya Pradesh (1988-89 to 2017-18) (In Per cent)**

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	99.60	11.34	-10.94
<b>Period- II (1998-99 to 2007-08)</b>	102.01	8.76	-10.77
<b>Period- III (2008-09 to 2017-18)</b>	36.69	60.69	2.62
<b>Overall (1988-89 to 2017-18)</b>	25.89	69.28	4.83

Source: Author's own commutation from compiled time series data.

Thus it could be summarized from the above analysis that area effect was prime contributor in period-I and II but in case of period-III and overall yield effect was major contributor to increase the production of green gram in Madhya Pradesh.

#### **Pigeon pea:**

It is observed from the Table 4.57 and figure 4.33 that, the growth in production of pigeon pea during overall period was mainly achieved through area and yield, while interaction effect had negative effect on change in production of pigeon pea in Madhya Pradesh. The area and yield effect contributed 59.63 and 41.93 per cent, respectively, while interaction effect had negative impact of -1.56 per cent.

During period-I, yield effect and area effect were mainly responsible to change in the production while interaction effect had negative effect on change in production of crop. The yield and area effect contributed 78.54 and 27.53 per cent, respectively,

while interaction effect had negative impact of -6.07 per cent. The growth in production of pigeon pea during period-II was mainly achieved through area and yield, while interaction effect had negative effect on change in production of pigeon pea in Madhya Pradesh. The area and yield effect contributed 53.28 and 48.51 per cent, respectively, while interaction effect had negative impact of -1.79 per cent. During period-III, yield effect and area effect were mainly responsible to change in the production while interaction effect had negative effect on change in production of crop. The yield and area effect contributed 57.43 and 48.17 per cent, respectively, while interaction effect had negative impact of -5.60 per cent. Similar results were reported by Sandeep *et al.* (2016) in area effect, yield effect and their interaction effect of Pigeon pea in western Vidarbha during 1983-84 to 2012-13.

**Table 4.57: Per cent contribution of area, yield and their interaction on production of Pigeon pea in Madhya Pradesh (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	27.53	78.54	-6.07
<b>Period- II</b> (1998-99 to 2007-08)	53.28	48.51	-1.79
<b>Period- III</b> (2008-09 to 2017-18)	48.17	57.43	-5.60
<b>Overall</b> (1988-89 to 2017-18)	59.63	41.93	-1.56

Source: Author's own commutation from compiled time series data.

Thus it could be observed from the above table that area effect was prime contributor in period-II and Overall but in case of period-I and period-III yield effect was major contributor to increase the production of pigeonpea in Madhya Pradesh.

#### **4.2.3 Sources of output growth in Uttar Pradesh:**

##### **Gram:**

Results of decomposition of growth of gram output is presented in the Table 4.58 and figure 4.34. It was revealed from the table that during overall period, area effect was mainly responsible for the output growth of gram accounting for 138.29 per cent of the total output growth while yield effect and interaction effect had negative effect on production with -0.91 and -37.38 per cent, respectively.

The growth in production of pigeon pea during period-I was mainly achieved through area and yield, while interaction effect had negative effect on change in production of gram in Uttar Pradesh. The area and yield effect contributed 93.24 and 7.36 per cent, respectively, while interaction effect had negative impact of -0.60 per cent. During period-II, area effect was more dominant than yield and interaction effect. In this period the output of gram was increased by 79.16 per cent due to expansion of area while 18.00 and 2.84 per cent due to increased yield and rest of growth by interaction effect. The growth in production of gram in Uttar Pradesh during period-III was mainly achieved through interaction and area expansion. The contribution of interaction in the production growth was 94.54 per cent. The area effect was positive (36.55%) and yield effect was observed negative (31.09%). Similar results were reported by Kalmakar (2001) in area effect, yield effect and their interaction effect of Gram in Maharashtra during 1961-62 to 1997-98.

**Table 4.58: Per cent contribution of area, yield and their interaction on production of Gram in Uttar Pradesh (1988-89 to 2017-18)**

(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	93.24	7.36	-0.60
<b>Period- II (1998-99 to 2007-08)</b>	79.16	18.00	2.84
<b>Period- III (2008-09 to 2017-18)</b>	36.55	-31.09	94.54
<b>Overall (1988-89 to 2017-18)</b>	138.29	-0.91	-37.38

Source: Author's own commutation from compiled time series data.

Thus it could be observed from the above table that area effect was prime contributor in period-I and Overall period. During period-II area effect was major contributor to increase the production of gram in Uttar Pradesh, in case of period-III interaction effect was mainly responsible to increase in production.

#### **Lentil:**

The relative contribution of area, yield and their interaction to change in production of lentil is presented in the Table 4.59 and figure 4.35. It was revealed from the table that during overall period, the growth in production of lentil was mainly achieved through area and yield, while interaction effect had negative effect

on change in production of lentil in Uttar Pradesh. The area and yield effect contributed 110.14 and 43.70 per cent, respectively, while interaction effect had negative effect of -53.84 per cent.

During period-I, area effect was mainly responsible for the output production of lentil accounting for 262.98 per cent of the total output growth while yield effect and interaction effect had negative effect on production with -129.94 and -33.04 per cent, respectively. During period-II, change in production of lentil was mainly due to interaction effect and area effect for Uttar Pradesh. The yield effect had negative bearing on production. The interaction effect and area effect contributed 84.88 and 39.82 per cent, respectively of production growth while yield effect had negative contribution to the extent of -24.70 per cent. The growth in production of lentil during period-III was mainly achieved through yield and interaction while area effect had negative effect on change in production of lentil in Uttar Pradesh. The yield effect and interaction effect contributed 90.28 and 12.80 per cent, respectively, while area effect had negative impact of -3.08 per cent. Similar results were reported by Kumar et al. (2009) in area effect, yield effect and their interaction effect of lentil in India during 1970-71 to 2006-07.

**Table 4.59: Per cent contribution of area, yield and their interaction on production of Lentil in Uttar Pradesh (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	262.98	-129.94	-33.04
<b>Period- II (1998-99 to 2007-08)</b>	39.82	-24.70	84.88
<b>Period- III (2008-09 to 2017-18)</b>	-3.08	90.28	12.80
<b>Overall (1988-89 to 2017-18)</b>	110.14	43.70	-53.84

Source: Author's own commutation from compiled time series data.

Thus it could be observed from the above analysis that area effect was major contributor in period-I and Overall period. During period-II interaction effect was major contributor to increase the production of lentil in Uttar Pradesh, while in case of period-III yield effect was mainly responsible to increase in production.

### **Black gram:**

Decomposition of production growth into its constituent forces for black gram is presented in the Table 4.60 and figure 4.36. It was revealed from the table that, during overall period and period-III however area effect turned out to most powerful factor in the growth of black gram in Uttar Pradesh with 73.29 and 105.71 per cent share respectively. Yield effect in both period (overall period and Period-III) was also positive with 36.10 and 10.30 per cent respectively while interaction effect had negative effect contribution in both period with -9.39 and -16.01 per cent respectively. The growth in production of black gram during period-I was mainly achieved through area and yield, while interaction effect had negative effect on change in production of gram in Uttar Pradesh. The area and yield effect contributed 74.28 and 26.09 per cent, respectively, while interaction effect had negative impact of -0.37 per cent. During period-II the growth in production of black gram was mainly achieved through yield and area, while interaction effect had negative effect on change in production of gram in Uttar Pradesh. The area and yield effect contributed 99.57 and 8.95 per cent, respectively, while interaction effect had negative impact of -8.52 per cent. Similar results were reported by Bairwa *et al* (2020) in area effect, yield effect and their interaction effect of Black gram in India during 1998-99 to 2017-18.

**Table 4.60: Per cent contribution of area, yield and their interaction on production of Black gram in Uttar Pradesh (1988-89 to 2017-18)**  
(In Per cent)

<b>Period</b>	<b>Area effect</b>	<b>Yield effect</b>	<b>Interaction effect</b>
<b>Period- I (1988-89 to 1997-98)</b>	74.28	26.09	-0.37
<b>Period- II (1998-99 to 2007-08)</b>	8.95	99.57	-8.52
<b>Period- III (2008-09 to 2017-18)</b>	105.71	10.30	-16.01
<b>Overall (1988-89 to 2017-18)</b>	73.29	36.10	-9.39

Source: Author's own commutation from compiled time series data.

Thus it could be observed from the above analysis that area effect was more dominant in period-I, III and Overall period. During period-II yield effect was major contributor to increase the production of black gram in Uttar Pradesh.

### Green gram:

Table 4.61 and figure 4.37 presents the contribution of various forces to the output growth of green gram in Uttar Pradesh state. As revealed from the table that, during overall period, interaction effect accounted for 54.54 per cent of the total output growth while contribution of area was 29.66 per cent and that of yield to the extent 15.80 per cent.

During period-I, area effect was more dominant than yield and interaction effect. In this period the output of green gram was increased by 68.25 per cent due to expansion of area while 21.72 and 10.03 per cent due to increased yield and rest of growth by interaction effect. The change in production was negative during period-II as evidenced by negative effect of productivity with -1245.83 per cent. The interaction effect was quite high during this period to the extent of 1335.72 per cent and area effect was small with 10.11 per cent on production. However high interaction effect neutralized by negative yield effect. During period-III, the interaction effect was solely accountable to boost up the green gram crop production although yield and interaction effect have positive contribution. The change in production during this period was due to interaction effect (52.99%) and area effect (29.25%) while yield effect was observed positive (17.56%). Similar results were reported by Bairwa *et al.* (2020) in area effect, yield effect and their interaction effect of Green gram in India during 1998-99 to 2017-18.

**Table 4.61: Per cent contribution of area, yield and their interaction on production of Green gram in Uttar Pradesh (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	68.25	21.72	10.03
<b>Period- II (1998-99 to 2007-08)</b>	10.11	-1245.83	1335.72
<b>Period- III (2008-09 to 2017-18)</b>	29.25	17.56	52.99
<b>Overall (1988-89 to 2017-18)</b>	29.66	15.80	54.54

Source: Author's own commutation from compiled time series data.

It is thus observed that general interaction effect was responsible for an increase in production of green gram in Uttar Pradesh during period-II, III and overall while area effect was responsible in period-I to increase in production.

### **Pigeon pea:**

The relative contribution of area, yield and their interaction to change in production of lentil is presented in the Table 4.62 and figure 4.38. It was revealed from the table that during overall period, the growth in production of pigeon pea was mainly achieved through area and yield effect, while interaction effect had negative effect on change in production of pigeon pea in Uttar Pradesh. The area and yield effect contributed 63.21 and 41.91 per cent, respectively, while interaction effect had negative effect of -5.12 per cent

During period-I, the yield effect was solely accountable to increase the pigeon pea crop production although area and interaction effect have positive contribution. The change in production during this period was due to yield effect (85.35%) and area effect (9.93%) while interaction effect was observed positive (4.72%). In period-II yield effect, area and interaction effect were continued to be as the powerful factor in increasing production of pigeon pea with 60.99, 36.53 and 2.49 per cent, respectively. During period-III, increase in production of pigeon pea was mainly due to yield effect and interaction effect with 254.41 per cent and 252.10 per cent contribution, respectively while area effect was negative on production of pigeon pea with -406.51 per cent contribution. Kalmakar (2001) in area effect, yield effect and their interaction effect of Tur in Maharashtra during 1961-62 to 1997-98.

**Table 4.62: Per cent contribution of area, yield and their interaction on production of Pigeon pea in Uttar Pradesh (1988-89 to 2017-18)**  
(In Per cent)

<b>Period</b>	<b>Area effect</b>	<b>Yield effect</b>	<b>Interaction effect</b>
<b>Period- I (1988-89 to 1997-98)</b>	9.93	85.35	4.72
<b>Period- II (1998-99 to 2007-08)</b>	36.53	60.99	2.49
<b>Period- III (2008-09 to 2017-18)</b>	-406.51	254.41	252.10
<b>Overall (1988-89 to 2017-18)</b>	63.21	41.91	-5.12

Source: Author's own commutation from compiled time series data.

Thus the growth in production was achieved mainly due to expansion of acreage during overall period. Yield effect was more powerful to increase in output of period-I, II and III

#### 4.2.4 Sources of output growth in Maharashtra:

##### Gram:

Results of decomposition of growth of gram output are presented in the Table 4.63 and figure 4.39. It was observed from the table that, during overall period, change in the production of gram was mainly due to interaction and area effect for Maharashtra as a whole. The yield effect had positive bearing on production. The interaction and area effect were contributed as high 44.64 and 44.56 per cent, respectively of total production growth while yield effect had positive contribution to the extent of 10.80 per cent.

**Table 4.63: Per cent contribution of area, yield and their interaction on production of Gram in Maharashtra (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	-15.87	158.71	-42.84
<b>Period- II (1998-99 to 2007-08)</b>	49.33	37.51	13.15
<b>Period- III (2008-09 to 2017-18)</b>	45.81	14.62	39.57
<b>Overall (1988-89 to 2017-18)</b>	44.56	10.80	44.64

Source: Author's own commutation from compiled time series data.

During period-I change in the production of gram in Maharashtra was mainly due to its yield effect. The area and interaction however had negative bearing on production. The yield effect contributed as high as 158.71 per cent of total output growth while area and interaction elements had negative contribution to the extent of -15.71 and -42.84 per cent, respectively. The change in production during period-II was due to area (49.33%), yield (37.51%) while interaction effect was also observed positive (13.15%). During period-III, change in the production of gram was mainly due to the area effect. The yield and interaction effect also had positive bearing on production. The area effect contributed high as 45.81 per cent while yield and

interaction elements had positive contribution to the extent of 14.62 and 39.57 per cent, respectively. Kalmakar (2001) in area effect, yield effect and their interaction effect of Gram in Maharashtra during 1961-62 to 1997-98.

Thus, the observed growth in production of gram in Maharashtra was mainly due to area and interaction effect during overall period. In the period-II yield effect was the most powerful element to increase of production while area effect was major factor in increasing production of gram during period-II and period- III.

### **Lentil:**

The Table 4.64 and figure 4.40 represented the contribution area, productivity and their interaction to the production growth of lentil in Maharashtra state. It was observed from the table that during overall period the contribution of area effect (172.21%) to production growth of lentil in the state was the highest followed by yield effect (8.01%) and then interaction effect on production was negative (-80.22%).

During period-I, change in production of lentil was mainly due to area effect and interaction effect for Maharashtra. The yield effect had negative bearing on production. The area effect and interaction effect contributed 101.06 and 14.40 per cent, respectively of production growth while yield effect had negative contribution to the extent of -15.46 per cent. During period-II, change in production of lentil was mainly due to interaction effect and area effect for Maharashtra. The yield effect had negative bearing on production. The interaction effect and area effect contributed 107.99 and 1.53 per cent, respectively on production growth while yield effect had negative contribution to the extent of -9.52 per cent. During period-III, increase in production of lentil was mainly due to yield effect and area effect with 122.80 and 29.42 per cent contribution respectively while interaction effect was negative effect on production of lentil with -52.22 per cent contribution. Similar results were reported by Kumar (2009) in area effect, yield effect and their interaction effect of lentil in India during 1970-71 to 2006-07.

**Table 4.64: Per cent contribution of area, yield and their interaction on production of Lentil in Maharashtra (1988-89 to 2017-18)**

(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	101.06	-15.46	14.40
<b>Period- II (1998-99 to 2007-08)</b>	1.53	-9.52	107.99
<b>Period- III (2008-09 to 2017-18)</b>	29.42	122.80	-52.22
<b>Overall (1988-89 to 2017-18)</b>	172.21	8.01	-80.22

Source: Author's own commutation from compiled time series data.

It is thus clear that area effect was responsible for increase in production during period-I and overall. During period-II interaction effect was more dominant to change in output while yield effect was more responsible to boost up in production during period-III.

#### **Black gram:**

The relative contribution of area, yield and their interaction to produce of black gram calculated and presented in the Table 4.65 and figure 4.41. It was revealed from the Table that, during overall period the growth in production of black gram was mainly achieved through interaction and yield effect. The contribution of interaction effect in the production growth was 587.68 per cent. The yield effect was positive (75.16%) and area effect was negative (-562.84%).

The growth in output of black gram during period-I was mainly achieved through area and interaction, while yield effect had negative effect on change of production. The area and interaction effect contributed 263.47 and 229.67 per cent, respectively, while yield effect had negative impact of -393.13 per cent. During period-II the change in production of black gram in Maharashtra was mainly due to its productivity growth. The area and interaction effect had however negative bearing on production. The yield effect contributed as high as 241.44 per cent of total output growth while area and interaction elements had negative contribution to the extent of -7.03 and -134.41 per cent, respectively. During period-III, change in production of black gram was mainly due to yield effect and interaction effect for Maharashtra. The

area effect had negative bearing on production. The yield effect and interaction effect contributed 83.56 and 33.47 per cent, respectively of production growth while area effect had negative contribution to the extent of -17.03 per cent. Similar results were reported by Bairwa *et al.* (2020) in area effect, yield effect and their interaction effect of Black gram in India during 1998-99 to 2017-18.

**Table 4.65: Per cent contribution of area, yield and their interaction on production of Black gram in Maharashtra (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	263.47	-393.13	229.67
<b>Period- II</b> (1998-99 to 2007-08)	-7.03	241.44	-134.41
<b>Period- III</b> (2008-09 to 2017-18)	-17.03	83.56	33.47
<b>Overall</b> (1988-89 to 2017-18)	-562.84	75.16	587.68

Source: Author's own commutation from compiled time series data.

Thus the observed growth in black gram of Maharashtra production was mainly due to interaction and yield effect during overall period. During period-I area effect and interaction effect were major factors in increasing production of black gram. In the period-II and III yield effect was the most powerful element to increase in production.

#### **Green gram:**

The Table 4.66 and figure 4.42 represented the contribution area, productivity and their interaction to the production growth of green gram in Maharashtra state. It was observed from the table that during overall period the contribution of area effect (152.90%) to production growth of green gram in the state was the highest followed by yield effect (73.80%) and then interaction effect on production was negative (-126.70%).

The growth in production of green gram during period-I was mainly achieved through area and yield, while interaction effect had negative effect on change in production of green gram in Maharashtra. The area and yield effect contributed 53.61 and 51.99 per cent, respectively, while interaction effect had negative impact of -5.60 per cent. During period-II change in the production of green gram in Maharashtra was

mainly due to its yield effect. The area and interaction however had negative bearing on production. The yield effect contributed as high as 319.22 per cent of total output growth while area and interaction elements had negative contribution to the extent of -40.57 and -178.65 per cent, respectively. During period-III, increased in production of green gram was mainly due to interaction effect and yield effect with 180.32 per cent and 28.97 per cent contribution respectively while area effect was negative effect on production of pigeon pea with -109.28 per cent contribution. Latika *et al.* (2015) in area effect, yield effect and their interaction effect of total pulses in India during 1950-51 to 2014-15

**Table 4.66: Per cent contribution of area, yield and their interaction on production of Green gram in Maharashtra (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	53.61	51.99	-5.60
<b>Period- II</b> (1998-99 to 2007-08)	-40.57	319.22	-178.65
<b>Period- III</b> (2008-09 to 2017-18)	-109.28	28.97	180.32
<b>Overall</b> (1988-89 to 2017-18)	152.90	73.80	-126.70

Source: Author's own commutation from compiled time series data.

Thus the growth in production was achieved through area and interaction effect during period-I and overall period, respectively. During period-II only yield effect was responsible to improve in production of green gram in Maharashtra while interaction effect and yield effect also responsible for growth in production of green gram in period-III.

#### **Pigeon pea:**

Table 4.67 and figure 4.43 presents the contribution of various forces to the output growth of pigeon pea in Maharashtra state. As revealed from the table that during overall period, yield effect accounted for 40.40 per cent of the total output growth while contribution of area was 25.00 per cent and that of interaction effect to the extent 34.60 per cent.

During period-I, increase in production of pigeon pea was mainly due to yield effect and interaction effect with 126.91 per cent and 3.86 per cent contribution respectively while area effect was negative on production of pigeon pea with -30.77 per cent contribution. During period-II, yield effect and area effect were mainly responsible for the output growth of pigeon pea accounting for 54.27 per cent and 49.83 per cent of the total output growth of pigeon pea in Maharashtra while interaction effects on production was negative accounting -4.10 per cent. During period-III, change in the production of pigeon pea was mainly due to the yield effect. The area and interaction effect also had positive bearing on production. The yield effect contributed high as 59.97 per cent while interaction and area elements had positive contribution to the extent of 27.71 and 12.32 per cent, respectively. More et al. (2015) in area effect, yield effect and their interaction effect of pigeon pea in Gujarat state during 1960-61 to 2010-11

**Table 4.67: Per cent contribution of area, yield and their interaction on production of Pigeon pea in Maharashtra (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	-30.77	126.91	3.86
<b>Period- II (1998-99 to 2007-08)</b>	49.83	54.27	-4.10
<b>Period- III (2008-09 to 2017-18)</b>	12.32	59.97	27.71
<b>Overall (1988-89 to 2017-18)</b>	25.00	40.40	34.60

Source: Author's own commutation from compiled time series data.

It is thus clear from the foregoing discussion that the increase in the output of pigeon pea in Maharashtra was mainly because of increase in yield of this crop in all the periods under study.

#### **4.2.5 Sources of output growth in Karnataka:**

##### **Gram:**

Decomposition of production growth into area, productivity and interaction components in the different periods for gram crop is presented in the Table 4.68 and figure 4.44. It was revealed from the Table that, the change in production during

overall period was due to area effect (77.00%) interaction effect (12.23%) and yield effect was observed positive (10.77%).

The increase in production of gram in Karnataka due to area effect and interaction effect while yield effect had negative impact on output of the gram in period-I. The area effect and interaction effect were contributed 98.62 and 38.99 per cent, respectively. The yield effect had observed negative effect on produce of gram with -37.64 per cent. During period-II, area effect and yield effect were mainly responsible for the output growth of gram accounting for 102.92 per cent and 26.54 per cent of the total output growth of gram in Karnataka while interaction effects on production was negative accounting -29.46 per cent. During period-III, change in the production of gram was mainly due to the area effect. The yield and interaction effect also had positive bearing on production. The area effect contributed high as 67.51 per cent while yield and interaction elements had positive contribution to the extent of 3.34 and 29.15 per cent, respectively. Shekhawat (2016) in area effect, yield effect and their interaction effect of Gram in Rajasthan state during 2002-03 to 2012-13.

**Table 4.68: Per cent contribution of area, yield and their interaction on production of Gram in Karnataka (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I</b> (1988-89 to 1997-98)	98.65	-37.64	38.99
<b>Period- II</b> (1998-99 to 2007-08)	102.92	26.54	-29.46
<b>Period- III</b> (2008-09 to 2017-18)	67.51	3.34	29.15
<b>Overall</b> (1988-89 to 2017-18)	77.00	10.77	12.23

Source: Author's own commutation from compiled time series data.

It is thus clear from the foregoing discussion that the increase in the output of gram in Karnataka was mainly because of increase in area of this crop in all the periods under study.

#### **Black gram:**

Table 4.69 and figure 4.45 represented the contribution area, productivity and their interaction to the output growth of black gram in Karnataka. It was revealed

from the table that, during overall growth in output of black gram was mainly achieved through area and interaction, while yield effect had negative effect on change of production. The area and interaction effect contributed 105.95 and 19.92 per cent, respectively, while yield effect had negative impact of -25.87 per cent.

During period-I, area effect was mainly responsible for the output production of black gram accounting for 359.13 per cent of the total output growth while yield effect and interaction effect had negative effect on production with -190.63 and -68.50 per cent, respectively. In period-II yield effect, area and interaction effect were continued to be as the powerful factor in increasing production of black gram with 48.85, 41.27 and 9.88 per cent, respectively. During period-III the yield effect and area was solely accountable to boost up the production of the black gram although interaction effect had positive contribution. The yield effect and area effect contributed 49.23 and 47.56 per cent, respectively, while interaction elements had positive contribution to the extent of 3.21 per cent. More et al. (2015) in area effect, yield effect and their interaction effect of pigeon pea in Gujarat state during 1960-61 to 2010-11

**Table 4.69: Per cent contribution of area, yield and their interaction on production of Black gram in Karnataka (1988-89 to 2017-18)**  
(In Per cent)

<b>Period</b>	<b>Area effect</b>	<b>Yield effect</b>	<b>Interaction effect</b>
<b>Period- I (1988-89 to 1997-98)</b>	359.13	-190.63	-68.50
<b>Period- II (1998-99 to 2007-08)</b>	41.27	48.85	9.88
<b>Period- III (2008-09 to 2017-18)</b>	47.56	49.23	3.21
<b>Overall (1988-89 to 2017-18)</b>	105.95	-25.87	19.92

Source: Author's own commutation from compiled time series data.

It is thus observed that area effect was more dominant factor in period-I and overall period while yield effect was more powerful factor to increase in production of black gram in Karnataka during period-II and III.

### Green gram:

Table 4.70 and figure 4.16 presents the contribution of various forces to the output growth of green gram in Karnataka state. It was revealed from the table that, the growth in output of green gram during overall period was mainly achieved through interaction effect alone, while yield effect and area effect had negative effect on change of production. The interaction effect contributed 627.28 per cent. The yield effect and area effect had negative impact of -295.46 and -241.82 per cent.

During period-I, increase in production of green gram was mainly due to yield effect and area effect with 131.03 per cent and 15.79 per cent contribution respectively while interaction effect was negative on production of green gram with – 46.82 per cent contribution. During period-II, change in production of green gram was mainly due to area effect and yield effect with 53.37 per cent and 50.58 per cent contribution respectively while interaction effect had negative impact on production of green gram with -3.95 per cent contribution. During period-III the yield effect was solely accountable to boost up the production of the green gram although area and interaction effect had positive contribution. The yield effect was contributed 84.12 per cent while area and interaction elements had positive contribution to the extent of 13.88 and 2.00 per cent, respectively. Similar results were reported by Singh and Bansal (2020) in area effect, yield effect and their interaction effect of Green gram in Punjab state during 1985-86 to 2017-18.

**Table 4.70: Per cent contribution of area, yield and their interaction on production of Green gram in Karnataka (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	15.79	131.03	-46.82
<b>Period- II (1998-99 to 2007-08)</b>	53.37	50.58	-3.95
<b>Period- III (2008-09 to 2017-18)</b>	13.88	84.12	2.00
<b>Overall (1988-89 to 2017-18)</b>	-241.82	-295.46	627.28

Source: Author's own commutation from compiled time series data.

Thus it could be concluded that interaction effect was most powerful factor to boost up the production of green gram in Karnataka during overall period. During

period-I and III, yield effect was dominant factor to increase in production of green gram. During period-II, area effect was mainly responsible to increase in production of green gram in Karnataka state.

**Pigeon pea:**

The relative contribution of area, yield and their interaction to produce of pigeon pea calculated and presented in the Table 4.71 and figure 4.47. It was revealed from the table that, during overall period the growth in production of pigeon pea was mainly achieved through interaction and yield effect. The contribution of interaction effect and yield effect in the production growth were 62.35 and 39.56 per cent. The contribution of area effect was negative on production of pigeon pea with -1.91 per cent.

**Table 4.71: Per cent contribution of area, yield and their interaction on production of Pigeon pea in Karnataka (1988-89 to 2017-18)**  
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
<b>Period- I (1988-89 to 1997-98)</b>	144.24	6.52	-50.76
<b>Period- II (1998-99 to 2007-08)</b>	37.31	44.86	17.83
<b>Period- III (2008-09 to 2017-18)</b>	-12.21	43.89	68.31
<b>Overall (1988-89 to 2017-18)</b>	-1.91	39.56	62.35

Source: Author’s own commutation from compiled time series data.

During period-I, increase in production of pigeon pea was mainly due to area effect and yield effect with 144.24 per cent and 6.52 per cent contribution respectively while interaction effect was negative on production of green gram with -50.76 per cent contribution. During period-II the yield effect was solely accountable to boost up the production of the pigeon pea although area and interaction effect had positive contribution. The yield effect contributed 44.86 per cent while area and interaction elements had positive contribution to the extent of 37.31 and 17.83 per cent, respectively. During period-III the growth in production of pigeon pea was mainly achieved through interaction and yield effect. The contribution of interaction effect on the production growth was 68.31 per cent. The yield effect was positive (43.89%) and area effect was negative (-12.21%). Similar results were reported by Singh and Bansal

(2020) in area effect, yield effect and their interaction effect of Pigeon pea in Punjab state during 1985-86 to 2017-18.

Thus it could be concluded interaction effect was most powerful factor to boost up the production of pigeon pea in Karnataka during period-III and overall period. During period-I, area effect was dominant factor to increase in production of pigeonpea. During period-II, yield effect was mainly responsible to increase in production of pigeon pea.

### **4.3 Instability analysis of the major pulse crops in major selected states of India**

The issue of instability is a serious concern for the farmers as it is directly related to inconsistent earnings. It causes a barrier between the total demand and actual supply of the commodity. The instability in area, production and productivity of major pulse crops in India is important to understand whether there is stable growth in the performance of gram, lentil, black gram, green gram and pigeon pea crops. It helps us to find out the bottlenecks in their performance and gives us ideas to formulate an appropriate plan and action to improve the efficiency of farmers. The analysis of instability also helps to find out which crops performed well in the region in terms of area, production and productivity.

In every economy, the issue of instability is a major problem. Risk and uncertainties are always associated with the agricultural sector. To judge the improvement in agricultural sector, measurement of the growth along with instability is essential. It is also helpful to understand how much these factors have varied from set path. Under this section, Cuddy Della Valle Instability index was used to measure the instability in area, production and productivity of major pulses viz., gram, green gram, black gram, lentil and pigeon pea in Rajasthan, Madhya Pradesh, Uttar Pradesh, Maharashtra and Karnataka.

#### **4.3.1 Instability analysis of major pulse crops in India**

##### **4.3.1.1 Instability analysis of major pulse crops in Rajasthan**

**Gram-**The instability in area, production and productivity of gram in Rajasthan are presented in the Table 4.72. It was revealed from the table that among area, production and productivity of gram, the maximum variability was found in production at 42.37 per cent followed by area (34.37%) and productivity (16.47%) in

the state. Similar findings were also presented by Kathale *et al.* (2015) in Nagpur division of Maharashtra.

**Lentil-** The instability in area, production and productivity of lentil in Rajasthan are also presented in the same Table 4.72 and figure 4.48. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability was very high in production of lentil. The Cuddy Della-Valla Instability Index was found to be 52.11 per cent in production followed by area (45.10%) and productivity (13.57%) of lentil in Rajasthan. Similar findings were also presented by Agarwal *et al.* (2012) in area, production and productivity of arhar crop in India.

**Black gram-**The variability in area, production and productivity of black gram in Rajasthan are presented in the Table 4.72 and figure 4.48. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in production of black gram in Rajasthan was found highest at the rate of 55.13 per cent followed by area (35.65%) and productivity (27.63%) in the state. Similar findings were also presented by Ahmad *et al.* (2018) in area, production and productivity of pulse crops in Eastern India.

**Green gram-** The instability in area, production and productivity of green gram are depicted in table 4.72 and figure 4.48. It was observed from the table that highest CDVI index of green gram was recorded in production (49.70%) followed by productivity (43.62%) and area (16.83%) in Rajasthan. Similar findings were also presented by Netharvadi and Yeledhalli (2016) in area, production and productivity of sesame crop in Bengaluru Division.

**Pigeon pea-** The results of instability in area, production and productivity of pigeon pea are showed in table 4.72 and figure 4.48. It was expressed in the table that area, production and productivity of pigeon pea were instable at the rate of 52.29, 50.24 and 34.62 per cent respectively, in the state. Similar findings were also presented by Netharvadi and Yeledhalli (2016) in area, production and productivity of tur crops in Bengaluru Division.

**Table 4.72: Instability in area, production and productivity of selected pulse crops in Rajasthan (1988-89 to 2017-18)**

(In Per cent)

Crops	Area	Production	Productivity
Gram	34.47	42.37	16.57
Lentil	45.10	52.11	13.57
Black gram	35.65	55.13	27.63
Green gram	16.83	49.79	43.62
Pigeon pea	52.29	50.24	34.62

Source: Author's own commutation from compiled time series data.

Therefore, it was concluded from the study that area and production of selected pulse crops were highly instable in Rajasthan except area under green gram. Subsequently, the productivity of green gram and pigeon pea were also more instable while gram and black gram were found medium instable. In the mean, time productivity of lentil was very less instable.

#### 4.3.1.2 Instability analysis of major pulse crops in Madhya Pradesh

**Gram-**The instability in area, production and productivity of gram in Madhya Pradesh are presented in the Table 4.73 and figure 4.49. It was revealed from the table that among area, production and productivity of gram, the maximum variability was found in production at 26.42 per cent followed by productivity (10.43 per cent) and area (7.61 per cent) in the state. Similar findings were also presented by Gajbhiye *et al.* (2010) in Vidarbha Region of Maharashtra.

**Lentil-** The instability in area, production and productivity of lentil in Madhya Pradesh are also presented in the same Table 4.73 and figure 4.49. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability was very high in production of lentil. The Cuddy Della-Valla Instability Index was found to be 24.05 per cent in production followed by productivity (18.74%) and area (7.48%) of lentil in the state. Similar findings were also presented by Uddin *et al.* (2015) in area, production and productivity of pulse crop in Bangladesh.

**Black gram-** The variability in area, production and productivity of black gram in Madhya Pradesh are presented in the Table 4.73 and figure 4.49. It was revealed from

the table that during entire study period (1988-89 to 2017-18), the instability in production of black gram was found highest at the rate of 50.90 per cent followed by area (20.01%) and productivity (16.98%) in the state. Similar findings were also presented by Ahmad *et al.* (2018) in area, production and productivity of pulse crops in Eastern India.

**Green gram-** The instability in area, production and productivity of green gram are depicted in Table 4.73 and figure 4.49. It was observed from the table that highest CDVI index of green gram was recorded in production (59.25%) followed by area (38.32%) and productivity (16.29%) in the state. Similar findings were also presented by Bairwa *et al.* (2020) in area, production and productivity of green gram crop in Rajasthan.

**Pigeon pea-** The results of instability in area, production and productivity of pigeon pea shown in Table 4.73 and figure 4.49. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in production of pigeon pea was found highest at the rate of 21.62 per cent followed by productivity (17.00%) and area (9.70%) in the state. Similar findings were also presented by Choudhary and Panwar (2010) in area, production and productivity of pigeon pea crops in Marathadwa Region of Maharashtra.

**Table 4.73: Instability in area, production and productivity of selected pulse crops in Madhya Pradesh (1988-89 to 2017-18)**

(In Per cent)

Crops	Area	Production	Productivity
Gram	7.61	26.42	10.43
Lentil	7.48	24.05	18.74
Black gram	20.01	50.90	16.98
Green gram	38.32	59.25	16.29
Pigeon pea	9.70	21.62	17.00

Source: Author's own commutation from compiled time series data.

Therefore, it was concluded from the study that production of black gram and green gram were highly instable and area of green gram was also highly instable, while production of gram, lentil and pigeon pea were medium instable in Madhya

Pradesh. In case of area of gram, lentil and pigeon pea were less instable and black gram was medium instable. In the mean time, productivity of lentil, black gram, green gram and pigeon pea were medium instable while productivity of gram was less instable.

#### **4.3.1.3 Instability analysis of major pulse crops in Uttar Pradesh**

**Gram-** The instability in area, production and productivity of gram in Uttar Pradesh are presented in the Table 4.74 and figure 4.50. It was revealed from the table that among area, production and productivity of gram, the maximum variability was found in production at 16.27 per cent followed by productivity (14.84 per cent) and area (8.85 per cent) in the state. Similar findings were also presented by Devraj *et al.* (2006) in area, production and productivity of chick pea Madhya Pradesh.

**Lentil-** The instability in area, production and productivity of lentil in Uttar Pradesh are also presented in the same Table 4.74 and figure 4.50. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability was very high in production of lentil. The Cuddy Della-Valla Instability Index was found to be 14.82 per cent in production followed by productivity (10.57 %) and area (9.89%) of lentil in the state. Similar findings were also presented by Bairwa *et al.* (2020) in area, production and productivity of pigeon pea crop in Rajasthan.

**Black gram-** The variability in area, production and productivity of black gram in Uttar Pradesh are presented in the Table 4.74 and figure 4.50. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in production of black gram was found highest at the rate of 20.14 per cent followed by area (19.56%) and productivity (12.40%) in the state. Similar findings were also presented by Bairwa *et al.* (2020) in area, production and productivity of black gram crop in Rajasthan.

**Green gram-** The instability in area, production and productivity of green gram are depicted in table 4.74 and figure 4.50. It was observed from the table that highest CDVI index of green gram was recorded in production (44.98%) followed by area (25.45%) and productivity (21.47%) in the state. Similar findings were also presented Netharvadi and Yeledhalli (2016) in area, production and productivity of sesame crop in Bengaluru Division.

**Pigeon pea-** The results of instability in area, production and productivity of pigeon pea are shown in Table 4.74 and figure 4.50. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in productivity of pigeon pea was found highest at the rate of 14.15 per cent followed by production (12.82%) and area (7.09%) in the state. Similar findings were also presented by Ahirwal *et al.* (2007) in area, production and productivity of pigeon pea crops in India.

**Table 4.74: Instability in area, production and productivity of selected pulse crops in Uttar Pradesh (1988-89 to 2017-18)**

(In Per cent)

Crops	Area	Production	Productivity
Gram	8.85	16.27	14.84
Lentil	9.89	14.82	10.57
Black gram	12.40	20.14	19.56
Green gram	25.45	44.98	21.47
Pigeon pea	7.09	12.82	14.15

Source: Author's own commutation from compiled time series data.

Therefore, it was concluded from the study that production of green gram was highly instable and production of gram and black gram were medium instable while lentil and pigeon pea were less instable in Uttar Pradesh. In case of area gram, lentil, black gram and pigeon pea were less instable and green gram was medium instable. In the mean time, productivity of black gram and green gram were medium instable while productivity of gram, lentil and pigeon pea were less instable.

#### **4.3.1.4 Instability analysis of major pulse crops in Maharashtra**

**Gram-** The instability in area, production and productivity of gram in Maharashtra are presented in the Table 4.75 and figure 4.51. It was revealed from the table that among area, production and productivity of gram, the maximum variability was found in production at 28.14 per cent followed by area (15.66 per cent) and productivity (15.05 per cent) in the state. Similar findings were also presented Devraj *et al.* (2014) in area, production and productivity of chickpea in Maharashtra.

**Lentil-** The instability in area, production and productivity of lentil in Maharashtra are also presented in the same Table 4.75 and figure 4.51. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability was very high in production of lentil. The Cuddy Della-Valla Instability Index was found to be 40.46 per cent in production followed by area (29.69%) and productivity (16.45%) of lentil in the state. Similar findings were also presented by Bairwa *et al.* (2020) in area, production and productivity of lentil crop in Rajasthan.

**Black gram-**The variability in area, production and productivity of black gram in Maharashtra are presented in the Table 4.75 and figure 4.51. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in production of black gram was found highest at the rate of 35.61 per cent followed by productivity (23.23%) and area (21.71%) in the state. Similar findings were also presented by Ahmad *et al.* (2018) in area, production and productivity of pulse crops in Eastern India.

**Green gram-** The instability in area, production and productivity of green gram are depicted in Table 4.75 and figure 4.51. It was observed from the table that highest CDVI index of green gram was recorded in production (31.42%) followed by productivity (28.50%) and area (10.68%) in the state. Similar findings were also presented by Netharvadi and Yeledhalli (2016) in area, production and productivity of sesame crop in Bengaluru Division.

**Pigeon pea-** The results of instability in area, production and productivity of pigeon pea are shown in Table 4.75 and figure 4.51. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in production of pigeon pea was found highest at the rate of 23.40 per cent followed by productivity (21.20%) and area (5.48%) in the state. Similar findings were also presented by Thakur and Singh. (2012) in area, production and productivity of pigeon pea crops in Madhya Pradesh.

**Table 4.75: Instability in area, production and productivity of selected pulse crops in Maharashtra (1988-89 to 2017-18)**

(In Per cent)

Crops	Area	Production	Productivity
Gram	15.66	28.14	15.05
Lentil	29.69	40.46	16.45
Black gram	21.71	35.61	23.23
Green gram	10.68	31.42	28.50
Pigeon pea	5.48	23.40	21.20

Source: Author's own commutation from compiled time series data.

Therefore, it was concluded from the study that production of lentil, black gram and green gram were highly instable and production of gram and pigeon pea were medium instable in Maharashtra. In case of area, green gram and pigeon pea were very less instable while gram, lentil and black gram were medium instable. In the mean, time productivity of selected crops were medium instable.

#### 4.3.1.5 Instability analysis of major pulse crops in Karnataka

**Gram-**The instability in area, production and productivity of gram in Karnataka are presented in the Table 4.76 and figure 4.52. It was revealed from the table that among area, production and productivity of gram, the maximum variability was found in production at 32.70 per cent followed by area (31.83 per cent) and productivity (15.65 per cent) in the state. Similar findings were also presented by Kathale *et al.* (2015) in Nagpur division of Maharashtra.

**Black gram-**The variability in area, production and productivity of black gram in Karnataka are presented in the Table 4.76 and figure 4.52. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in production of black gram was found highest at the rate of 48.82 per cent followed by productivity (44.84%) and area (13.93%) in the state. Similar findings were also presented by Bairwa *et al.* (2020) in area, production and productivity of black gram crop in Rajasthan.

**Green gram-** The instability in area, production and productivity of green gram are depicted in Table 4.74 and figure 4.52. It was observed from the table that highest

CDVI index of green gram was recorded in production (54.10%) followed by productivity (37.48%) and area (26.67%) in the state. Similar findings were also presented by Netharvadi and Yeledhalli (2016) in area, production and productivity of sesame crop in Bengaluru Division.

**Pigeon pea-** The results of instability in area, production and productivity of pigeon pea are shown in Table 4.76 and figure 4.52. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in production of pigeon pea was found highest at the rate of 35.34 per cent followed by productivity (23.68%) and area (15.66%) in the state. Similar findings were also presented by Netharvadi and Yeledhalli (2016) in area, production and productivity of tur crops in Bengaluru Division.

**Table 4.76: Instability in area, production and productivity of selected pulse crops in Karnataka (1988-89 to 2017-18)**

(In Per cent)

Crops	Area	Production	Productivity
Gram	31.83	32.70	15.65
Black gram	13.93	48.82	44.84
Green gram	26.67	54.10	37.48
Pigeon pea	15.66	35.34	23.68

Source: Author's own commutation from compiled time series data.

Therefore, it was concluded from the study that production of selected crops were highly instable in Karnataka. In case of area, gram was highly instable and black gram was less instable while green gram and pigeon pea were medium instable. In the mean time, productivity of gram and pigeon pea were medium instable while productivity of black gram and green gram were highly instable.

#### **4.3.2 Causes of instability in acreage of selected pulse crops**

The log linear response function was fitted to compute the causes of instability in area of selected pulse crops in Rajasthan.

#### 4.3.2.1 Causes of instability in acreage of selected pulse crops in Rajasthan

**Gram-** The two independent variables namely  $A_{t-1}$  and  $C_t$  showed higher correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported high correlation with dependent variable was kept in the model. The results of causes of instability in area of gram are presented in Table 4.77. It was observed from the results that lagged area of gram ( $A_{t-1}$ ) was found to be 0.298, lagged acreage of competitive crop ( $C_{t-1}$ ) wheat was found to be -1.000 and rainfall during sowing period (S) along with lagged rainfall ( $S_{t-1}$ ) were found to be 0.102 and -0.034, respectively. All the variables together explained 31.6 per cent of variability in the acreage of gram in Rajasthan. The coefficient of lagged area of competitive crop ( $C_{t-1}$ ) was significant and negative. Rainfall, lagged rainfall and lagged area of gram were non-significant in the state. Similar findings were also presented by Sood (2017) for pulse crops in Rajasthan.

Therefore, it could be concluded from the findings that chickpea growers in Rajasthan showed contrary response to lagged area under its competing crop i.e. the decrease in area of competing crop in last year season, thereby that was tendency to increase the area under gram in Rajasthan.

**Lentil-** Two independent variables viz.,  $A_{t-1}$  and  $C_t$  recorded higher positive correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported high correlation with dependent variable was retained in the response model. The output of causes of instability in lentil area is presented in Table 4.77. It was revealed from the findings that lagged area of lentil ( $A_{t-1}$ ) was found to be 0.523, lagged acreage of competitive wheat crop ( $C_{t-1}$ ) was found to be -0.488, rainfall was found to be 0.050 and lagged rainfall was found to be 0.032 were accounted as high as 67 per cent of variability in lentil area in Rajasthan. The coefficient of lagged area of lentil crop ( $A_{t-1}$ ) was positive and statistically significant. While rainfall, lagged rainfall and lagged area of competing crop were non-significant in the state. Similar findings were also presented by Tingre *et al.* (2006) of wheat crops in Vidarbha.

Therefore, it could be concluded from the findings that lentil growers in Rajasthan were quite responsive to lagged area under lentil crop. It means the increase

in area of lentil in last year season, there is tendency to increase the area under lentil in Rajasthan.

**Black gram-**The output of causes of instability in black gram area is presented in Table 4.77. It was revealed from the findings that lagged area of black gram ( $A_{t-1}$ ) was found to be 0.674, lagged acreage of competitive crop ( $C_{t-1}$ ) pearl millet was found to be -0.379, rainfall was found to be 0.146 and lagged rainfall was found to be 0.102 and, variables together explained 59.5 per cent of variability in black gram area in Rajasthan. The coefficient of all variables namely rainfall, lagged area of black gram and competing crop were statistically non-significant. Though, area of competitive crop ( $C_t$  and  $C_{t-1}$ ) was non-significant but negative. Similar findings were also presented by Tuteja *et al.* (2006) in urad crops in India.

Therefore, it could be concluded from the findings that black gram growers in Rajasthan were quite responsive to lagged area of its competing crop. It means the decrease in area of competing crop ( $C_t$  and  $C_{t-1}$ ), there is tendency to increase the area under black gram in Rajasthan.

**Green gram-** There two independent variables namely  $A_{t-1}$  and  $C_t$  showed higher correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported high correlation with dependent variable was retained in the fitted model. The output of causes of instability in green gram area is presented in Table 4.77. It was revealed from the findings that lagged area of green gram ( $A_{t-1}$ ) was found to be 0.924, lagged acreage of competitive crop ( $C_{t-1}$ ) pearl millet was found to be -0.692, rainfall was found to be 0.079 and lagged rainfall was found to be 0.066 variables were accounted as high as 88.4 per cent of variability in green gram area in Rajasthan. The coefficient of lagged area of green gram ( $A_{t-1}$ ) and weather were positive and statistically non-significant. Though lagged area of competing crop were also non-significant but negative. Similar findings were also presented by Anug *et al.* (2006) of pulse crops in Myanwar.

Therefore, it could be concluded from the findings that green gram growers in Rajasthan were negatively responsive to lagged area under this crop. It means the decrease in area of its competing crop in last year season, there is tendency to increase the area under green gram in the state.

**Pigeon pea-** The two independent variables viz.,  $A_{t-1}$  and  $C_t$  recorded higher positive correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported high correlation with dependent variable was retained in the response model. The output of causes of instability in pigeon pea area is presented in Table 4.77. It was revealed from the findings that lagged area of pigeon pea ( $A_{t-1}$ ) was found to be 0.709, lagged acreage of competitive crop ( $C_{t-1}$ ) pearl millet was found to be -0.327, rainfall was found to be 0.428 and lagged rainfall was found to be 0.012 variables were together explained 45.4 per cent of variability in pigeon pea area in Rajasthan. The coefficient of lagged area of pigeon pea ( $A_{t-1}$ ) was positive and statistically significant. While rainfall ( $S$  and  $S_{t-1}$ ) and lagged area of competing crop were non-significant in the state. Similar findings were also presented by Tuteja *et al.* (2006) of arhar crops in India.

Therefore, it could be concluded from the findings that pigeon pea growers in Rajasthan were directly associated to lagged area under pigeon pea crop. It means when the area of pigeon pea in last year season was increased, then the area under pigeon pea also increased in Rajasthan.

**Table 4.77. Estimated acreage response function (log linear form) of selected crops in Rajasthan (1988-89 to 2017-18)**

Variable	Gram	Lentil	Black gram	Green gram	Pigeon pea
<b>Constant (B<sub>0</sub>)</b>	0.227 (0.561)	-2.426 (1.066)	0.609 (1.432)	-0.867 (0.854)	-1.125 (1.544)
<b>A<sub>(t-1)</sub></b>	0.298 (0.191)	0.523** (0.249)	0.674 (0.208)	0.924 (0.074)	0.709* (0.216)
<b>C<sub>t</sub></b>	-	-	-0.454 (0.622)	-	-
<b>C<sub>(t-1)</sub></b>	-1.000** (0.577)	-0.488 (0.883)	-0.379 (0.495)	-0.692 (0.311)	-0.327 (0.555)
<b>S</b>	0.102 (0.092)	0.050 (0.139)	0.146 (0.139)	0.079 (0.086)	0.428 (0.150)
<b>S<sub>(t-1)</sub></b>	-0.034 (0.092)	0.032 (0.120)	0.102 (0.171)	0.066 (0.113)	0.012 (0.199)
<b>R<sup>2</sup></b>	0.316	0.670	0.595	0.884	0.454

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

#### 4.3.2.2 Causes of instability in acreage of selected pulse crops in Madhya Pradesh

**Gram-** The two independent variables namely  $A_{t-1}$  and  $C_t$  were showed higher correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was kept in the model. The results of causes of instability in area of gram are presented in Table 4.78. It was observed from the results that lagged area of gram ( $A_{t-1}$ ) was found to be 0.524, lagged acreage of competitive crop ( $C_{t-1}$ ) wheat was found to be -0.344 and rainfall during sowing period (S) along with lagged rainfall ( $R_{t-1}$ ) were found to be -0.012 and -0.014 respectively. All the variables together explained 71.4 per cent of variability in the acreage of gram in Madhya Pradesh. The coefficient of lagged area of gram and area its competitive crop ( $C_{t-1}$ ) wheat were significant. Rainfall and lagged rainfall were non-significant in the state. Similar findings were also presented by Tingre *et al.* (2006) of wheat crops in Vidarbha.

Therefore, it could be concluded from the findings that chickpea growers in Madhya Pradesh showed contrary response to lagged area under its competing crop i.e. the decrease in area of competing crop in last year season, thereby that was tendency to increase the area under gram in Madhya Pradesh.

**Lentil-** Two independent variables viz.,  $A_{t-1}$  and  $C_t$  were recorded higher positive correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was retained in the response model. The output of causes of instability in lentil area is presented in Table 4.78. It was revealed from the findings that lagged area of lentil ( $A_{t-1}$ ) was found to be 0.801, lagged acreage of competitive wheat ( $C_{t-1}$ ) was found to be -0.241, rainfall was found to be -0.028 and lagged rainfall was found to be 0.015 variables were accounted as high as 83.8 per cent of variability in lentil area in Madhya Pradesh. The coefficient of lagged area of lentil crop ( $A_{t-1}$ ) and lagged seasonal rainfall were positive and statistically non significant. While rainfall and lagged area of competing crop were negative and non-significant in the state. . Similar findings were also presented by Tuteja *et al.* (2006) of Arhar crops in India.

Therefore, it could be concluded from the findings that lentil growers in Madhya Pradesh were quite responsive to lagged area under lentil crop. It means the

increase in area of lentil in last year season, there is tendency to increase the area under lentil in Madhya Pradesh.

**Black gram-**The output of causes of instability in black gram area is presented in Table 4.78. It was revealed from the findings that lagged area of black gram ( $A_{t-1}$ ) was found to be 1.178, lagged acreage of competitive crop ( $C_{t-1}$ ) soybean was found to be 0.461, rainfall was found to be -0.177 and lagged rainfall was found to be -0.008, variables were together explained 83.8 per cent of variability in black gram area in Rajasthan. The coefficient of all variables namely rainfall, and lagged rainfall were statistically non-significant. Though, lagged area of competitive crop ( $C_{t-1}$ ) and lagged area of black gram were statistically non-significant but positive. Similar findings were also presented by Grace *et al.* (2014) of pulse crops in India.

Therefore, it could be concluded from the findings that black gram growers in Madhya Pradesh were quite responsive to lagged area under black gram crop. It means the increase in area of black gram in last year season, there is tendency to increase the area under black gram in Madhya Pradesh.

**Green gram-** There two independent variables namely  $A_{t-1}$  and  $C_t$  were showed higher correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was retained in the fitted model. The output of causes of instability in green gram area is presented in Table 4.78. It was revealed from the findings that lagged area of green gram ( $A_{t-1}$ ) was found to be 0.998, lagged acreage of competitive crop ( $C_{t-1}$ ) soybean was found to be -1.328, rainfall was found to be 0.829 and lagged rainfall was found to be 0.066 variables were accounted as high as 82.2 per cent of variability in green gram area in Madhya Pradesh. The coefficient of lagged area of green gram ( $A_{t-1}$ ) was positive and statistically non-significant while rainfall was positive and statistically significant. Though lagged area of competing crop were also significant but negative. . Similar findings were also presented by Boyal *et al.* (2015) of cumin crop in Rajasthan.

Therefore, it could be concluded from the findings that green gram growers in Madhya Pradesh were negatively responsive to lagged area under this crop. It means the decrease in area of its competing crop in last year season, there is tendency to increase the area under green gram in the state.

**Pigeon pea-** The two independent variables viz.,  $A_{t-1}$  and  $C_t$  were recorded higher positive correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was retained in the response model. The output of causes of instability in pigeon pea area is presented in Table 4.78. It was revealed from the findings that lagged area of pigeon pea ( $A_{t-1}$ ) was found to be 1.058, lagged acreage of competitive crop ( $C_{t-1}$ ) soybean was found to be -0.203, rainfall was found to be -0.257 and lagged rainfall was found to be -0.211 variables were together explained 86.7 per cent of variability in pigeon pea area in Madhya Pradesh. The coefficient of lagged area of pigeon pea ( $A_{t-1}$ ) was positive and statistically non significant. While rainfall ( $S$  and  $S_{t-1}$ ) and lagged area of competing crop were negative and statistically non-significant in the state. Similar findings were also presented by Tuteja *et al.* (2006) of arhar crops in India.

Therefore, it could be concluded from the findings that pigeon pea growers in Madhya Pradesh were directly associated to lagged area under pigeon pea crop. It means when the area of pigeon pea in last year season was increased, then the then the area under pigeon pea also increased in Madhya Pradesh.

**Table 4.78. Estimated acreage response function (log linear form) of selected crops in Madhya Pradesh (1988-89 to 2017-18)**

Variables	Gram	Lentil	Black gram	Green gram	Pigeon pea
<b>Constant (B<sub>0</sub>)</b>	0.274 (0.174)	0.023 (0.159)	0.569 (1.104)	-4.173 (1.844)	1.768 (0.796)
<b>A<sub>(t-1)</sub></b>	0.524* (0.193)	0.801 (0.100)	1.178 (0.199)	0.998 (0.105)	1.058 (0.091)
<b>C<sub>t</sub></b>	-	-	-	-	-
<b>C<sub>(t-1)</sub></b>	-0.344** (0.184)	-0.241 (0.174)	0.461 (0.386)	-1.328** (0.671)	-0.203 (0.255)
<b>S</b>	-0.012 (0.018)	-0.028 (0.018)	-0.177 (0.153)	0.829* (0.254)	-0.257** (0.110)
<b>S<sub>(t-1)</sub></b>	-0.014 (0.019)	0.015 (0.018)	-0.008 (0.161)	-0.066 (0.278)	-0.211** (0.113)
<b>R<sup>2</sup></b>	0.714	0.838	0.838	0.822	0.867

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

#### 4.3.2.3 Causes of instability in acreage of selected pulse crops in Uttar Pradesh

**Gram**-The output of causes of instability in gram area are presented in Table 4.79. It was revealed from the findings that lagged area of gram ( $A_{t-1}$ ) was found to be 0.536, lagged acreage of competitive crop ( $C_{t-1}$ ) wheat was found to be -2.509, rainfall was found to be -0.115 and lagged rainfall was found to be -0.037, variables were together explained 77.7 per cent of variability in gram area in Uttar Pradesh. The coefficient of all variables namely rainfall, and lagged rainfall, lagged area of competing crop were statistically non-significant and negative. Though, area of competitive crop ( $C_t$  and  $C_{t-1}$ ) was non-significant but negative while lagged area of gram was statistically non-significant and positive. Similar findings were also presented by Sood (2017) of pulse crops in Rajasthan.

Therefore, it could be concluded from the findings that gram growers in Uttar Pradesh were quite responsive to lagged area of its competing crop. It means the decrease in area of competing crop ( $C_t$  and  $C_{t-1}$ ), there is tendency to increase the area under gram in Uttar Pradesh.

**Lentil**-The causes of instability in lentil area are presented in Table 4.79. It was revealed from the findings that lagged area of lentil ( $A_{t-1}$ ) was found to be 0.584, lagged acreage of competitive crop ( $C_{t-1}$ ) wheat was found to be 0.509, rainfall was found to be -0.119 and lagged rainfall was found to be 0.009, variables were together explained 69.3 per cent of variability in lentil area in Uttar Pradesh. The coefficient of lagged area of lentil crop ( $A_{t-1}$ ) was positive and statistically significant. While rainfall, lagged rainfall and lagged area of competing crop were non-significant in the state. Similar findings were also presented by Tuteja *et al.* (2006) of masoor crops in India.

Therefore, it could be concluded from the findings that lentil growers in Uttar Pradesh were directly associated to lagged area under lentil crop. It means when the area of lentil in last year season was increased, then the then the area under lentil also increased in Uttar Pradesh.

**Black gram**-The output of causes of instability in black gram area are presented in Table 4.79. It was revealed from the findings that lagged area of black gram ( $A_{t-1}$ ) was found to be 0.992, lagged acreage of competitive crop ( $C_{t-1}$ ) paddy was found to be 0.216, rainfall was found to be -0.123 and lagged rainfall was found to be 0.125,

variables were together explained 89.6 per cent of variability in black gram area in Uttar Pradesh. The coefficient of all variables namely rainfall, and lagged rainfall were statistically non-significant. Though, lagged area of competitive crop ( $C_{t-1}$ ) and lagged area of black gram were statistically non-significant but positive. Similar findings were also presented by Anug *et al.* (2007) of pulse crops in India.

Therefore, it could be concluded from the findings that black gram growers in Uttar Pradesh were quite responsive to lagged area under black gram crop. It means the increase in area of black gram in last year season, there is tendency to increase the area under black gram in Uttar Pradesh.

**Green gram-** There two independent variables namely  $A_{t-1}$  and  $C_t$  showed higher correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was retained in the fitted model. The output of causes of instability in green gram area are presented in Table 4.79. It was revealed from the findings that lagged area of green gram ( $A_{t-1}$ ) was found to be 0.872, lagged acreage of competitive crop ( $C_{t-1}$ ) paddy was found to be -0.481, rainfall was found to be -0.359 and lagged rainfall was found to be 0.442 variables were accounted as high as 75.4 per cent of variability in green gram area in Uttar Pradesh. The coefficient of lagged area of green gram ( $A_{t-1}$ ) and lagged rainfall were positive and statistically non-significant. Though lagged area of competing crop and rainfall were also non-significant but negative. Similar findings were also presented by Dhaker (2007) of pulses crops in India.

Therefore, it could be concluded from the findings that green gram growers in Uttar Pradesh were negatively responsive to lagged area under this crop. It means the decrease in area of its competing crop in last year season, there is tendency to increase the area under green gram in the state

**Pigeon pea-**The output of causes of instability in pigeon pea area are presented in Table 4.79. It was revealed from the findings that lagged area of pigeon pea ( $A_{t-1}$ ) was found to be 0.866, lagged acreage of competitive crop ( $C_{t-1}$ ) paddy was found to be 0.663, rainfall was found to be -0.002 and lagged rainfall was found to be -0.046, variables were together explained 88.3 per cent of variability in pigeon pea area in Uttar Pradesh. The coefficient of all variables namely rainfall, lagged rainfall and competing crop ( $C_t$  and  $C_{t-1}$ ) were negative and statistically non-significant. Though,

area of pigeon pea crop ( $A_{t-1}$ ) was non-significant but positive. Similar findings were also presented by Gajja *et al.* (2008) of sesame crop in India.

Therefore, it could be concluded from the findings that pigeon pea growers in Uttar Pradesh were quite responsive to lagged area of its competing crop. It means the decrease in area of competing crop ( $C_t$  and  $C_{t-1}$ ), there is tendency to increase the area under pigeon pea in Uttar Pradesh.

**Table 4.79. Estimated acreage response function (log linear form) of selected crops in Uttar Pradesh (1988-89 to 2017-18)**

Variables	Gram	Lentil	Black gram	Green gram	Pigeon pea
<b>Constant (B<sub>0</sub>)</b>	7.195 (3.704)	2.063 (0.886)	-0.408 (1.517)	-1.030 (3.476)	2.071 (0.558)
<b>A<sub>(t-1)</sub></b>	0.536 (0.218)	0.584* (0.140)	0.992 (0.093)	0.872 (0.153)	0.866 (0.093)
<b>C<sub>t</sub></b>	-0.715 (2.618)	-1.231 (1.229)	-	-	-0.360 (0.483)
<b>C<sub>(t-1)</sub></b>	-2.509 (2.720)	0.509 (1.215)	0.216 (0.802)	-0.481 (1.747)	-0.663 (0.468)
<b>S</b>	-0.115 (0.072)	-0.119* (0.029)	0.123 (0.183)	-0.359 (0.404)	-0.002 (0.098)
<b>S<sub>(t-1)</sub></b>	-0.037 (0.064)	0.006 (0.033)	0.125 (0.179)	0.442 (0.398)	-0.046 (0.100)
<b>R<sup>2</sup></b>	0.777	0.693	0.896	0.754	0.883

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

#### 4.3.2.4 Causes of instability in acreage of selected pulse crops in Maharashtra

**Gram-** The two independent variables namely  $A_{t-1}$  and  $C_t$  showed higher correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was kept in the model. The results of causes of instability in area of gram are presented in Table 4.80. It was observed from the results that lagged area of gram ( $A_{t-1}$ ) was found to be 1.035, lagged acreage of competitive crop ( $C_{t-1}$ ) wheat was found to be -0.939 and rainfall during sowing period (S) along with lagged rainfall ( $S_{t-1}$ ) were found to be -0.039 and 0.002 respectively. All the variables together explained 93.7 per cent of variability in

the acreage of gram in Maharashtra. The coefficient of lagged area of competitive crop ( $C_{t-1}$ ) and rainfall were statistically non significant and negative. Lagged rainfall and Lagged area of gram were statistically non-significant and positive in the state. Similar findings were also presented by Sood (2017) of pulse crops in Rajasthan.

Therefore, it could be concluded from the findings that chickpea growers in Maharashtra showed contrary response to lagged area under its competing crop i.e. the decrease in area of competing crop in last year season, thereby that was tendency to increase the area under gram in Maharashtra.

**Lentil-** Two independent variables viz.,  $A_{t-1}$  and  $C_t$  recorded higher positive correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was retained in the response model. The output of causes of instability in lentil area are presented in Table 4.80. It was revealed from the findings that lagged area of lentil ( $A_{t-1}$ ) was found to be 0.573, lagged acreage of competitive wheat ( $C_{t-1}$ ) was found to be -0.771, rainfall was found to be -0.069 and lagged rainfall was found to be 0.060 variables were accounted as high as 46 per cent of variability in lentil area in Maharashtra. The coefficient of lagged area of lentil crop ( $A_{t-1}$ ) and lagged area of competing crop were statistically significant. While rainfall, lagged rainfall were non-significant in the state. Similar findings were also presented by Tuteja *et al.* (2006) of Arhar crops in India.

Therefore, it could be concluded from the findings that lentil growers in Maharashtra were quite responsive to lagged area under lentil crop. It means the increase in area of lentil in last year season, there is tendency to increase the area under lentil in Maharashtra.

**Black gram-** There two independent variables namely  $A_{t-1}$  and  $C_t$  showed higher correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was retained in the fitted model. The output of causes of instability in black gram area are presented in Table 4.80. It was revealed from the findings that lagged area of black gram ( $A_{t-1}$ ) was found to be 0.663, lagged acreage of competitive crop ( $C_{t-1}$ ) cotton was found to be -0.429, rainfall was found to be 0.056 and lagged rainfall was found to be -0.183 variables were accounted as high as 64.5 per cent of variability in black

gram area in Maharashtra. The coefficient of lagged area of black gram ( $A_{t-1}$ ) was positive and statistically significant. Though lagged area of competing crop and lagged area of rainfall were also non-significant but negative. Similar findings were also presented by Anug *et al.* (2007) of pulse crops in Myanmar.

Therefore, it could be concluded from the findings that black gram growers in Maharashtra were negatively responsive to lagged area under this crop. It means the decrease in area of its competing crop in last year season, there is tendency to increase the area under black gram in the state.

**Green gram-**The output of causes of instability in green gram area are presented in Table 4.80. It was revealed from the findings that lagged area of green gram ( $A_{t-1}$ ) was found to be 0.420, lagged acreage of competitive crop ( $C_{t-1}$ ) cotton was found to be -0.272, rainfall was found to be 0.142 and lagged rainfall was found to be -0.081, variables were together explained 78.2 per cent of variability in green gram area in Maharashtra. The coefficient of all variables namely lagged rainfall and lagged area of competing crop were statistically non-significant and negative. Though, area of competitive crop ( $C_t$  and  $C_{t-1}$ ) was non-significant but negative. Similar findings were also presented by Dhaker (2007) of oilseed crops in Rajasthan.

Therefore, it could be concluded from the findings that green gram growers in Maharashtra were quite responsive to lagged area of its competing crop. It means the decrease in area of competing crop ( $C_t$  and  $C_{t-1}$ ), there is tendency to increase the area under green gram in Maharashtra.

**Pigeon pea-** The two independent variables viz.,  $A_{t-1}$  and  $C_t$  recorded higher positive correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was retained in the response model. The output of causes of instability in pigeon pea area are presented in Table 4.80. It was revealed from the findings that lagged area of pigeon pea ( $A_{t-1}$ ) was found to be 0.305, lagged acreage of competitive crop ( $C_{t-1}$ ) pearl millet was found to be 0.113, rainfall was found to be 0.040 and lagged rainfall was found to be -0.070 variables were together explained 67.6 per cent of variability in pigeon pea area in Maharashtra. The coefficient of lagged area of pigeon pea ( $A_{t-1}$ ) was positive and statistically significant. While rainfall ( $S$  and  $S_{t-1}$ ) and lagged area of

competing crop were non-significant in the state. Similar findings were also presented by Tuteja *et al.* (2006) of arhar crops in India.

Therefore, it could be concluded from the findings that pigeon growers in Maharashtra were quite responsive to lagged area under pigeon pea crop. It means the increase in area of pigeonpea in last year season, there is tendency to increase the area under pigeon pea in Maharashtra.

**Table 4.80. Estimated acreage response function (log linear form) of selected crops in Maharashtra (1988-89 to 2017-18)**

Variables	Gram	Lentil	Black gram	Green gram	Pigeon pea
<b>Constant (B<sub>0</sub>)</b>	0.188 (0.145)	-0.059 (0.480)	1.294 (1.079)	1.247 (0.988)	0.435 (0.411)
<b>A<sub>(t-1)</sub></b>	1.035 (0.111)	0.573* (0.167)	0.663** (0.159)	0.420*** (0.225)	0.305 (0.185)
<b>C<sub>t</sub></b>	-	-	-	-0.476 (0.485)	-
<b>C<sub>(t-1)</sub></b>	-0.939 (0.172)	-0.771** (0.348)	-0.429 (0.542)	-0.232 (0.461)	0.113 (0.206)
<b>S</b>	-0.039 (0.030)	-0.069 (0.096)	0.056 (0.145)	0.142 (0.123)	0.040 (0.055)
<b>S<sub>(t-1)</sub></b>	0.002 (0.033)	0.060 (0.097)	-0.183 (0.144)	-0.081 (0.130)	-0.070 (0.055)
<b>R<sup>2</sup></b>	0.937	0.460	0.645	0.782	0.676

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

#### 4.3.2.5 Causes of instability in acreage of selected pulse crops in Karnataka

**Gram**-The output of causes of instability in gram area is presented in Table 4.81. It was revealed from the findings that lagged area of gram ( $A_{t-1}$ ) was found to be 0.925, lagged acreage of competitive crop ( $C_{t-1}$ ) wheat was found to be -1.148, rainfall was found to be -0.234 and lagged rainfall was found to be 0.139, variables were together explained 72.1 per cent of variability in gram area in Karnataka. The coefficient of all variables namely rainfall, lagged area of gram and lagged area of competing crop were statistically non-significant. Though, lagged rainfall was statistically significant and positive. Similar findings were also presented by Tuteja *et al.* (2006) of gram crops in India

Therefore, it could be concluded from the findings that gram growers in Karnataka were quite responsive to lagged area of its competing crop. It means the decrease in area of competing crop ( $C_{t-1}$ ), there is tendency to increase the area under gram in Karnataka.

**Black gram-**The output of causes of instability in black gram area is presented in Table 4.81. It was revealed from the findings that lagged area of black gram ( $A_{t-1}$ ) was found to be 0.603, lagged acreage of competitive crop ( $C_{t-1}$ ) paddy was found to be 0.708, rainfall was found to be  $-0.174$  and lagged rainfall was found to be  $-0.157$ , variables were together explained 46.1 per cent of variability in black gram area in Karnataka. The coefficient of all variables namely rainfall, lagged rainfall and lagged area of competitive crop ( $C_{t-1}$ ) were statistically non-significant. Though, and lagged area of black gram were statistically significant but positive. Similar findings were also presented by Tuteja *et al.* (2006) of urd crops in India.

Therefore, it could be concluded from the findings that black gram growers in Karnataka were quite responsive to lagged area under black gram crop. It means the increase in area of black gram in last year season, there is tendency to increase the area under black gram in Karnataka.

**Green gram-** There two independent variables namely  $A_{t-1}$  and  $C_t$  showed higher correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e.  $A_{t-1}$ , which reported highly correlation with dependent variable was retained in the fitted model. The output of causes of instability in green gram area is presented in Table 4.81. It was revealed from the findings that lagged area of green gram ( $A_{t-1}$ ) was found to be 0.270, lagged acreage of competitive crop ( $C_{t-1}$ ) paddy was found to be  $-2.434$ , rainfall was found to be  $-0.448$  and lagged rainfall was found to be  $-1.262$  variables were accounted as high as 44.1 per cent of variability in green gram area in Karnataka. The coefficient of lagged area of green gram ( $A_{t-1}$ ) was positive and statistically non-significant. Though lagged area of competing crop, rainfall and lagged rainfall were also non-significant but negative. Similar findings were also presented by Gajja *et al.* (2008) of sesame crops in Rajasthan

Therefore, it could be concluded from the findings that green gram growers Karnataka were negatively responsive to lagged area under this crop. It means the

decrease in area of its competing crop in last year season, there is tendency to increase the area under green gram in the state

**Pigeon pea**-The output of causes of instability in pigeon pea area is presented in Table 4.81. It was revealed from the findings that lagged area of pigeon pea ( $A_{t-1}$ ) was found to be 0.910, lagged acreage of competitive crop ( $C_{t-1}$ ) paddy was found to be -0.897, rainfall was found to be 0.211 and lagged rainfall was found to be -0.571, variables were together explained 65.8 per cent of variability in pigeon pea area in Karnataka. The coefficient of all variables namely lagged area of competing crop ( $C_{t-1}$ ) were negative and statistically non-significant while lagged rainfall was negative and statistically significant. Though, area of pigeon pea crop ( $A_{t-1}$ ) and rainfall was non-significant but positive. Similar findings were also presented by Tuteja *et al.* (2006) of arhar crops in India.

Therefore, it could be concluded from the findings that pigeon pea growers in Karnataka were quite responsive to lagged area of its competing crop. It means the decrease in area of competing crop ( $C_{t-1}$ ), there is tendency to increase the area under pigeon pea in Karnataka.

**Table 4.81. Estimated acreage response function (log linear form) of selected crops in Karnataka (1988-89 to 2017-18)**

Variables	Gram	Black gram	Green gram	Pigeon pea
<b>Constant (<math>B_0</math>)</b>	0.371 (0.394)	1.086 (1.344)	7.452 (2.195)	2.002 (1.524)
<b><math>A_{(t-1)}</math></b>	0.925 (0.135)	0.603* (0.169)	0.270 (0.181)	0.910 (0.171)
<b><math>C_t</math></b>	-	-	-	-
<b><math>C_{(t-1)}</math></b>	-1.148 (0.702)	0.708 (0.887)	-2.434 (1.449)	-0.897 (1.035)
<b>S</b>	-0.234 (0.112)	-0.174 (0.202)	-0.448 (0.347)	0.211 (0.257)
<b><math>S_{(t-1)}</math></b>	0.139** (0.111)	-0.157 (0.293)	-1.262 (0.462)	-0.571** (0.309)
<b><math>R^2</math></b>	0.721	0.461	0.441	0.658

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

### **4.3.3 Causes of variability in productivity of major pulses in selected states of Indian**

In order to measure the factors responsible for variability in pulse crops, productivity response log linear model was fitted for the selected states viz., Rajasthan, Madhya Pradesh, Uttar Pradesh, Karnataka and Maharashtra of India. During the study period (1988-89 to 2017-18), the findings in this regard are depicted in table 4.82 to 4.86 and elaborated as under:

#### **4.3.3.1 Causes of instability in productivity of selected pulse crops in Rajasthan**

**Gram-** The results of factors responsible for instability in productivity of gram is presented in Table 4.82. It was revealed from the table that seasonal rainfall and time trend variables together explained 18.2 per cent of instability in productivity of gram. The coefficient of time was 0.004 showing positive and significant trend. The impact of seasonal rainfall -0.004 which was negative and non-significant on the productivity of gram in Rajasthan. The productivity of gram was augmented over the year in Rajasthan.

**Lentil-** The results of causes of instability in productivity of lentil is presented in Table 4.82. It could be observed from the results that time trend and seasonal rainfalls together explained 19.6 per cent of variability in productivity of lentil in Rajasthan. The coefficient of seasonal rainfall was 0.077 which was negative and significant. Time trend factor 0.002 which was reported positive and non-significant impact on the productivity of lentil in Rajasthan. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall at the flowering stage of lentil in Rajasthan.

**Black gram-** The output of responsible factor for instability in yield of black gram is reported in Table 4.82. It was observed from the table that time trend and seasonal rainfalls together explained 46.5 per cent instability in productivity of black gram in Rajasthan. The regression coefficient of time trend was 0.005 and seasonal rainfalls was 0.426 which together recorded positive and significant impact on productivity of black gram in Rajasthan. It means productivity of black gram was increased with the increase in seasonal rainfall and time trend variables in the state.

**Green gram-**The results of factors responsible for instability in productivity of green gram is presented in Table 4.82. It was revealed from the table that rainfall and time

trend variables together explained 42.2 per cent of instability in productivity of green gram. The coefficient of seasonal rainfall was 0.906 showing positive and significant. Subsequently, the impact of time trend was 0.006, which was also positive but non-significant on the productivity of green gram in Rajasthan. The productivity of green gram was augmented due to increase in seasonal rainfall over the year in Rajasthan.

**Pigeon pea-** The findings of causes of instability in productivity of pigeon pea is presented in table 4.82. It was revealed from the results that time trend and seasonal rainfalls together explained 29 per cent of variability in productivity of pigeon pea in Rajasthan. The coefficient of seasonal rainfall was 0.412 which was positive and significant. Further, time trend factor was 0.004 which was also reported positive but non-significant impact on the productivity of pigeon pea in Rajasthan. The excess rainfall in cropped season recorded positive impact on the productivity of pigeon pea in Rajasthan.

**Table 4.82: Estimated yield response function (log linear form) of major pulse crops in Rajasthan (1988-89 to 2017-18)**

S. No	Variable	Gram	Lentil	Black gram	Green gram	Pigeon pea
1.	<b>Constant (B<sub>0</sub>)</b>	-5.901 (3.569)	-0.987 (2.576)	-9.591 (4.726)	-13.190 (9.744)	-6.983 (6.333)
2.	<b>T (Time)</b>	0.004** (0.002)	0.002 (0.001)	0.005** (0.002)	0.006 (0.005)	0.004 (0.003)
3.	<b>S</b>	-0.004 (0.051)	-0.077** (0.037)	0.426* (0.110)	0.906* (0.227)	0.412* (0.147)
4.	<b>R<sup>2</sup></b>	0.182	0.196	0.465	0.422	0.290

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

Therefore, it could be concluded from the above findings that during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of all selected crops in Rajasthan. Further, seasonal rainfall recorded positive impact on black gram, green gram and pigeon pea crops while on lentil and gram it was negative in Rajasthan.

#### **4.3.3.2 Causes of instability in productivity of selected pulse crops in Madhya Pradesh**

**Gram-** The results of factors responsible for instability in productivity of gram is presented in Table 4.83. It was revealed from the table that rainfall and time trend variables together explained 59.6 per cent of instability in productivity of gram. The coefficient of time and rainfall were 0.006 and 0.015 respectively, showing positive and non significant trend. The impact of seasonal rainfall was positive on the productivity of gram in Madhya Pradesh. The productivity of gram was augmented over the year in Madhya Pradesh.

**Lentil-** The results of causes of instability in productivity of lentil are presented in Table 4.83. It could be observed from the results that time trend and seasonal rainfalls together explained 24.4 per cent of variability in productivity of lentil in Madhya Pradesh. The coefficient of seasonal rainfall was -0.009 which was negative and statistically non significant. Time trend factor was found to be 0.002, which reported positive and significant impact on the productivity of lentil in Madhya Pradesh. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall at the flowering stage of lentil in Madhya Pradesh.

**Black gram-** The responsible factor for instability in yield of black gram is reported in Table 4.83. It was observed from the table that time trend and seasonal rainfalls together explained 57 per cent instability in productivity of black gram in Madhya Pradesh. The coefficient of seasonal rainfall was -0.013 which was negative and statistically non significant. Time trend factor was found to be 0.010, which reported positive and non significant impact on the productivity of black gram in Madhya Pradesh. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall at the flowering stage of black gram in Madhya Pradesh.

**Green gram-**The results of factors responsible for instability in productivity of green gram are presented in Table 4.84. It was revealed from the table that rainfall and time trend variables together explained 43.5 per cent of instability in productivity of green gram. The coefficient of seasonal rainfall was 0.131 showing positive and non significant. Subsequently, the impact of time trend was 0.008, which was also positive but non-significant on the productivity of green gram in Madhya Pradesh. The

productivity of green gram was augmented due to increase in seasonal rainfall over the year in Madhya Pradesh.

**Pigeon pea-** The findings of causes of instability in productivity of lentil are presented in Table 4.83. It was revealed from the results that time trend and seasonal rainfalls together explained 25 per cent of variability in productivity of pigeon pea in Madhya Pradesh. The coefficient of seasonal rainfall was 0.081 which was positive and non significant. Further, time trend factor was -0.002 which was reported negative but non-significant impact on the productivity of pigeon pea in Madhya Pradesh. The productivity of pigeon pea was augmented over the year in Madhya Pradesh.

**Table 4.83: Estimated yield response function (log linear form) of selected crops in Madhya Pradesh (1988-89 to 2017-18)**

S.No	Variable	Gram	Lentil	Black gram	Green gram	Pigeon pea
1.	<b>Constant (B<sub>0</sub>)</b>	-9.951 (2.058)	-9.337 (4.083)	-18.107 (3.612)	-13.638 (3.585)	6.166 (5.003)
2.	<b>T (Time)</b>	0.006 (0.001)	0.006* (0.002)	0.010 (0.002)	0.008* (0.002)	-0.002 (0.002)
3.	<b>S</b>	0.015 (0.022)	-0.009 (0.004)	-0.013 (0.194)	0.131 (0.193)	0.081 (0.269)
4.	<b>R<sup>2</sup></b>	0.596	0.244	0.570	0.435	0.250

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

Therefore, it could be concluded from the above findings that during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of all selected crops except pigeon pea crop in Madhya Pradesh. Further, seasonal rainfall was recorded positive impact on gram, green gram and pigeon pea crops while on lentil and black gram it was negative in Madhya Pradesh.

#### **4.3.3.3 Causes of instability in productivity of selected pulse crops in Uttar Pradesh**

**Gram-** The results of factors responsible for instability in productivity of gram are presented in Table 4.84. It was revealed from the table that rainfall and time trend variables together explained 37.4 per cent of instability in productivity of gram. The coefficient of seasonal rainfall was -0.150 which was negative and significant. Time trend factor 0.001 which was reported positive and non-significant impact on the productivity of gram in Uttar Pradesh. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall in Uttar Pradesh.

**Lentil-** The results of causes of instability in productivity of lentil are presented in Table 4.84. It could be observed from the results that time trend and seasonal rainfalls together explained 16.1 per cent of variability in productivity of lentil in Uttar Pradesh. The coefficient of seasonal rainfall was -0.072 which was negative and significant. Time trend factor 0.001 which was reported positive and non-significant impact on the productivity of lentil in Uttar Pradesh. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall in Uttar Pradesh.

**Black gram-** The output of responsible factor for instability in yield of black gram are reported in Table 4.84. It was observed from the table that time trend and seasonal rainfall together explained 34.3 per cent instability in productivity of black gram in Uttar Pradesh. The coefficient of seasonal rainfall was 0.022 which was positive and statistically non significant. Time trend factor was found to be 0.007, which reported positive and significant impact on the productivity of black gram in Uttar Pradesh. The impact of seasonal rainfall were positive on the productivity of gram in Uttar Pradesh. The productivity of black gram was augmented over the year in Uttar Pradesh.

**Green gram-**The results of factors responsible for instability in productivity of green gram are presented in Table 4.84. It was revealed from the table that rainfall and time trend variables together explained 60.7 per cent of instability in productivity of green gram. The coefficient of seasonal rainfall was 0.009 showing positive and non significant. Subsequently, the impact of time trend was 0.014, which was also positive but non-significant on the productivity of green gram in Uttar Pradesh. The

productivity of green gram was augmented due to increase in seasonal rainfall over the year in Uttar Pradesh.

**Pigeon pea-** The findings of causes of instability in productivity of pigeonpea are presented in Table 4.84. It was revealed from the results that time trend and seasonal rainfalls together explained 42.5 per cent of variability in productivity of pigeon pea in Uttar Pradesh. The coefficient of seasonal rainfall was 0.282 which was positive and non significant. Further, time trend factor was -0.005 which was reported negative but statistically significant impact on the productivity of pigeon pea in Uttar Pradesh. The productivity of pigeon pea was augmented over the year in Uttar Pradesh.

**Table 4.84: Estimated yield response function (log linear form) of selected crops in Uttar Pradesh (1988-89 to 2017-18)**

S.No	Variable	Gram	Lentil	Black gram	Green gram	Pigeon pea
1.	<b>Constant (B<sub>0</sub>)</b>	2.814 (2.338)	3.652 (1.956)	-11.835 (4.326)	-24.687 (4.793)	10.988 (3.165)
2.	<b>T (Time)</b>	0.001 (0.001)	0.001 (0.001)	0.007* (0.002)	0.014 (0.002)	-0.005* (0.001)
3.	<b>S</b>	-0.150* (0.038)	-0.072** (0.032)	0.022 (0.192)	0.009 (0.212)	0.282 (0.140)
4.	<b>R<sup>2</sup></b>	0.374	0.161	0.343	0.607	0.425

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

Therefore, it could be concluded from the above findings that during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of all selected crops except pigeon pea crop in Uttar Pradesh. Further, seasonal rainfall was recorded positive impact on black gram, green gram and pigeon pea crops while on gram and lentil gram it was negative in Uttar Pradesh.

#### **4.3.3.4 Causes of instability in productivity of selected pulse crops in Maharashtra**

**Gram-** The output of responsible factor for instability in yield of gram are reported in Table 4.85. It was observed from the table that time trend and seasonal rainfalls together explained 46.2 per cent instability in productivity of gram in Maharashtra. The coefficient of seasonal rainfall was -0.0213 which was negative and statistically non significant. Time trend factor was found to be 0.007, which reported positive and non significant impact on the productivity of gram in Maharashtra. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall gram in Maharashtra.

**Lentil-** The results of factors responsible for instability in productivity of lentil are presented in Table 4.85. It was revealed from the table that rainfall and time trend variables together explained 26 per cent of instability in productivity of lentil. The coefficient of time and rainfall were 0.037 and 0.001 respectively, showing positive and non significant trend. The impact of seasonal rainfall were positive on the productivity of gram in Maharashtra. The productivity of lentil was augmented over the year in Maharashtra.

**Black gram-**The results of factors responsible for instability in productivity of black gram are presented in Table 4.85. It was revealed from the table that rainfall and time trend variables together explained 20 per cent of instability in productivity of black gram. The coefficient of seasonal rainfall was 0.193 showing positive and significant. Subsequently, the impact of time trend was 0.008, which was also positive but non-significant on the productivity of black gram in Maharashtra. The productivity of black gram was augmented due to increase in seasonal rainfall over the year in Maharashtra.

**Green gram-** The results of factors responsible for instability in productivity of green gram are presented in Table 4.85. It was revealed from the table that rainfall and time trend variables together explained 17 per cent of instability in productivity of green gram. The coefficient of seasonal rainfall was 0.006 showing positive and significant. Subsequently, the impact of time trend was 0.001, which was also positive but significant on the productivity of green gram in Maharashtra. The productivity of

green gram was augmented due to increase in seasonal rainfall over the year in Maharashtra.

**Pigeon pea**-The results of factors responsible for instability in productivity of pigeon pea are presented in Table 4.85. It was revealed from the table that rainfall and time trend variables together explained 41.7 per cent of instability in productivity of pigeon pea. The coefficient of seasonal rainfall was 0.597 showing positive and significant. Subsequently, the impact of time trend was 0.008, which was also positive but non-significant on the productivity of pigeon pea in Maharashtra. The productivity of green gram was augmented due to increase in seasonal rainfall over the year in Maharashtra.

**Table 4.85: Estimated yield response function (log linear form) of selected crops in Maharashtra (1988-89 to 2017-18)**

S.No	Variable	Gram	Lentil	Black gram	Green gram	Pigeon pea
1.	<b>Constant (B<sub>0</sub>)</b>	-11.296 (3.008)	0.928 (3.385)	-13.308 (22.633)	-2.010 (6.255)	-15.918 (4.453)
2.	<b>T (Time)</b>	0.007 (0.001)	0.001 (0.002)	0.008 (0.010)	0.001 (0.003)	0.008* (0.002)
3.	<b>S</b>	-0.023 (0.004)	0.037 (0.020)	0.193 (0.952)	0.606* (0.263)	0.597* (0.187)
4.	<b>R<sup>2</sup></b>	0.462	0.260	0.200	0.170	0.417

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

Therefore, it could be concluded from the above findings that during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of all selected crops in Maharashtra. Further, seasonal rainfall also recorded positive impact on all selected crops except gram crops in Maharashtra.

#### **4.3.35 Causes of instability in productivity of selected pulse crops in Karnataka**

**Gram**-The results of factors responsible for instability in productivity of gram are presented in Table 4.86. It was revealed from the table that rainfall and time trend variables together explained 50.7 per cent of instability in productivity of gram. The coefficient of seasonal rainfall and time trend were 0.022 and 0.009 respectively,

showing positive and non significant. The productivity of black gram was augmented due to increase in seasonal rainfall over the year in Karnataka.

**Black Gram**-The results of factors responsible for instability in productivity of black gram are presented in Table 4.86. It was revealed from the table that rainfall and time trend variables together explained 10 per cent of instability in productivity of black gram. The coefficient of seasonal rainfall and time trend were -0.001 and -0.002 respectively, showing negative and statistically non significant. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall gram in Karnataka.

**Green gram**-The results of factors responsible for instability in productivity of pigeon pea are presented in Table 4.86. It was revealed from the table that rainfall and time trend variables together explained 17.9 per cent of instability in productivity of pigeon pea. The coefficient of seasonal rainfall was -0.076 showing negative and significant. Subsequently, the impact of time trend was -0.010, which was also negative but significant on the productivity of green gram in Karnataka. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall in Karnataka.

**Pigeon pea**-The results of factors responsible for instability in productivity of pigeon pea are presented in Table 4.86. It was revealed from the table that rainfall and time trend variables together explained 43.2 per cent of instability in productivity of pigeon pea. The coefficient of seasonal rainfall was -0.056 showing negative and non significant. Subsequently, the impact of time trend was 0.011, which was also positive but significant on the productivity of pigeon pea in Karnataka. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall in Karnataka.

**Table 4.86: Estimated yield response function (log linear form) of selected crops in Karnataka (1988-89 to 2017-18)**

S.No	Variable	Gram	Black gram	Green gram	Pigeon pea
1.	<b>Constant (B<sub>0</sub>)</b>	-14.898 (3.401)	7.290 (11.268)	23.629 (10.046)	-18.393 (5.877)
2.	<b>T (Time)</b>	0.009 (0.002)	-0.002 (0.005)	-0.010** (0.005)	0.011* (0.003)
3.	<b>S</b>	0.022 (0.059)	-0.001 (0.397)	-0.076 (0.354)	-0.056 (0.207)
4.	<b>R<sup>2</sup></b>	0.507	0.100	0.179	0.432

Source: Author's own commutation from compiled time series data.

Note: Figures in parenthesis are standard error of Coefficient

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

Therefore, it could be concluded from the above findings that during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of gram and pigeon pea crops while negative influence on productivity of black gram and green gram crops in Karnataka. Further, seasonal rainfall was recorded positive impact on gram crop while negative influence on productivity of black gram green gram and pigeon pea crops in Karnataka.

#### **4.4 SEASONAL BEHAVIOUR IN PRICES OF SELECTED PULSE CROPS**

All agricultural commodities are subjected to an endless phenomena of price variation but prices of pulse crops have shown more fluctuation during the last 10 years. Seasonality in production of pulse crops, scarcity in their supply and their continuous demand throughout the year leads to high degree of price variation over the months/seasons of the year. The booms and depression in the prices over the months/seasons and nature of force associated therewith make it necessary to supply the behavior of prices of pulse crops in different months/seasons. Price fluctuation within a year introduce an element of uncertainty and effect the marketing decision and marketing ability of the farmers. The up and down movement in prices that occur with the same regulation during the year are termed as seasonal price variations. The seasonal component is defined as the intra-year pattern of variation that is repeated from year to year. The extent of price rise during the year reflects that intra-year price margin and determines the stocking behaviour of traders and returns to storage.

Seasonal price variations resemble a cycle covering a period of 12 months or less (Dorosh, Shahauddin, 2002 and Sharma, 2012).

In this chapter, an attempt has been made to study the seasonal variation in arrivals and prices of gram, lentil, black gram, green gram and pigeon pea with the help of central moving average of 12 months model of multiplicative form. The seasonal price analysis of monthly arrivals and prices of selected pulse crops were estimated for Rajasthan and Madhya Pradesh states.

#### **4.4.1 Seasonal index of major pulse crops in Rajasthan**

##### **Seasonal index of Gram in Rajasthan**

Gram is a rabi season crop of Rajasthan. The seasonal price and arrivals index of gram in KUMS, Bikaner is presented in the Table 4.87 and figure 53. It was revealed from the table that highest seasonal arrivals index of gram was observed in the month of June (112.61) followed by May (110.56), July (110.41) in KUMS, Bikaner. The decline in the arrivals was more prominent from July to January and reached to the lowest in January (87.27) in the KUMS, Bikaner. The arrivals indices of gram were more than 100 from April to August in the market.

During the study period (2008-2017), the highest seasonal price index of gram was recorded in the month of January (113.37) and the lowest (84.90) in the month of June in KUMS, Bikaner of Rajasthan. The period from May to June is post-harvest period of gram in Rajasthan.

Therefore, it could be analyzed from the table that there was an inverse relationship between price and arrivals of gram in the KUMS, Bikaner. It might be due to distress sale, lack of storage facilities and overdue burden of the farmers. Similar findings were reported by Sharma (2014) in arrivals and prices of gram from 2002-2012 in Bikaner market of Rajasthan.

**Table 4.87: Seasonal indices of monthly arrivals and prices of Gram in KUMS, Bikaner (2008-2017)**

(Arrivals and Price in Index)

Month	Arrivals	Price
January	<b>87.27</b>	<b>113.37</b>
February	89.68	105.47
March	98.31	100.23
April	105.48	93.40
May	110.56	94.11
June	<b>112.61</b>	<b>84.90</b>
July	110.41	86.24
August	104.41	96.94
September	97.15	106.29
October	99.46	104.90
November	94.53	104.15
December	90.15	110.00
<b>Total</b>	<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

### **Seasonal index of Lentil Crop in Rajasthan**

The seasonal indices of arrivals and price of lentil crop are presented in the Table 4.88 and figure 54. It was revealed from the table that the results were clearly indicated to existence of seasonality in arrivals and prices of lentil in KUMS, Bundi. The peak arrival of lentil was from February to June months. The arrival index of lentil in KUMS, Bundi were observed more than 100 during the months of February to June and the highest arrivals was observed in the month of May (112.62).

The price indices of lentil in KUMS Bundi were observed more than 100 during the months of August to February except September. The KUMS, Bundi showed highest price index in the month of November (129.30) and lowest in the month of May (77.22). The seasonality in lentil price began to decline as soon as the harvesting of new crop started.

Therefore, it could be observed from the table that there was inverse relationship between price and arrivals of lentil in the KUMS, Bundi. It might be due to marketed surplus was more than marketable surplus. Similar findings were reported

by Asmatoddin *et al.* (2009) in arrivals and prices of gram from 1996-97 to 2004-05 in Prabhani market of Maharashtra.

**Table 4.88: Seasonal indices of monthly arrivals and prices of Lentil crop in KUMS, Bundi (2008-2017)**

(Arrivals and Price in Index)

S.No.	Month	Arrivals	Price
1	January	98.08	115.26
2	February	100.11	108.47
3	March	109.51	91.02
4	April	108.84	82.20
5	May	<b>112.62</b>	<b>77.22</b>
6	June	109.82	78.86
7	July	99.50	96.56
8	August	94.18	104.45
9	September	95.24	86.31
10	October	95.09	115.48
11	November	<b>83.96</b>	<b>129.30</b>
12	December	93.06	114.87
<b>Total</b>		<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

### Seasonal index of Black gram crop in Rajasthan

Black gram is a kharif crop in Rajasthan. Seasonal indices of arrivals and prices of black gram are depicted in Table 4.89 and figure 55.. It was revealed from the table and figure that KUMS, Bundi witnessed the lowest arrivals indices during the month of July (89.85) and highest in the month of November (109.14). During the study period, more than 100 arrival index of black gram was recorded from November to May months with peak arrival index in the month of November in KUMs, Bundi.

The highest seasonal price index of black gram was found in the month of July (199.42) and lowest in the month of November (78.98). The seasonal price index of black gram in the KUMS, Bundi was more than 100 during the period of June to January except November month.

Thus, it could be observed from the table that there was contrary relationship between price and arrivals of black gram in the KUMS, Bundi. It might be due to lack

of storage facility with farmers in the Rajasthan. Similar findings were reported by Prakesh *et al.* 1995 in arrivals and prices of Urdbean in Uttar Pradesh.

**Table 4.89: Seasonal indices of monthly arrivals and prices of Black gram crop in KUMS, Bundi (2008-2017)**

(Arrivals and Price in Index)

S. No.	Month	Arrivals	Price
1	January	103.59	103.59
2	February	108.53	91.97
3	March	107.55	86.96
4	April	101.69	98.68
5	May	106.15	83.71
6	June	99.17	101.39
7	July	<b>89.85</b>	<b>119.42</b>
8	August	93.59	107.42
9	September	91.62	114.91
10	October	85.43	111.55
11	November	<b>109.14</b>	<b>78.98</b>
12	December	103.68	101.42
<b>Total</b>		<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

### Seasonal index of Green gram crop in Rajasthan

Like black gram, green gram is also cultivated in kharif season in Rajasthan, however, in some part of Rajasthan, it is also grown in jayad season. The seasonal indices of arrivals and prices of green gram are depicted by the Table 4.90 and figure 56. It was observed from the table and figure that KUMS, Kekari witnessed for the highest arrival index of green gram during the month of January (112.13) and the lowest during month of June (85.64). The KUMS, Kekari also reported more than 100 arrivals indices of green gram from November to April with peak arrivals in January.

In the KUMS, Kekari, the highest and lowest seasonal price index of green gram was found in the month of June (117.05) and January (88.56), respectively. During the study period, the KUMS, Kekari showed more than 100 seasonal price index from May to September months. At the same time, the peak level of seasonal price index in KUMS, Kekari was recorded in the month of June. It could be

concluded from the analysis that arrivals and price of green gram were represented negative association with price in KUMS, Kekari. It might be due to lack of storage facility of farmers in Rajasthan. Similar results were found by Basvaraja (1993) of major crops in Bijapur district of Karnataka.

**Table 4.90: Seasonal indices of monthly arrivals and prices of Green gram crop in KUMS, Kekari (2008-2017)**

(Arrivals and Price in Index)

S.No.	Month	Arrivals	Price
1	January	<b>112.13</b>	<b>88.56</b>
2	February	108.80	90.03
3	March	110.78	89.07
4	April	103.07	93.07
5	May	97.55	101.75
6	June	<b>85.64</b>	<b>117.05</b>
7	July	89.75	110.80
8	August	87.88	113.56
9	September	86.96	111.47
10	October	98.82	96.85
11	November	109.92	93.04
12	December	108.70	94.75
<b>Total</b>		<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

### Seasonal index of pigeon pea crop in Rajasthan

The seasonal indices of arrivals and prices of Pigeon pea in KUMS, Pratapgarh are presented in the Table 4.91 and figure 4.57. It was revealed from the table and figure that highest seasonal arrival index (115.09) of pigeon pea was recorded in the month of February in KUMS Pratapgarh and the smallest during the month of July (81.64). During October to March months, the KUMS, Pratapgarh showed more than 100 arrivals indices of pigeon pea and less than 100 from April to September. Higher arrival indices of pigeon pea were noticed immediately after harvest in the selected market.

During the same study period, the value of highest price index for pigeon pea was recorded during in the month of July (115.87) and lowest price index in the

month of February (81.89) in the KUMS Pratapgarh. The price index of pigeon pea in selected market was more than 100 during the month of May to September and less than 100 during October to April months.

Therefore, it could be notified from the table that there was inverse relationship between price and arrivals of pigeon pea in the KUMS, Pratapgarh. It might be due to distress sale made by pigeon pea growers in the KUMS Pratapgarh. Similar findings were reported by Choudhary and Pawar (2010) in arrivals and prices of pigeon pea from 1985-86 to 2004 -05 in Latur market of Maharashtra.

**Table 4.91: Seasonal indices of monthly arrivals and prices of Pigeon pea crop in KUMS, Pratapgarh (2008-2017)**

(Arrivals and Price in Index)

S. No.	Month	Arrivals	Price
1	January	109.92	88.71
2	February	<b>115.09</b>	<b>81.89</b>
3	March	110.53	88.89
4	April	99.81	99.40
5	May	88.93	111.97
6	Jun	89.70	115.50
7	July	<b>81.64</b>	<b>115.87</b>
8	August	85.14	115.14
9	September	97.66	100.96
10	October	106.21	94.55
11	November	106.35	95.83
12	December	109.03	91.30
<b>Total</b>		<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

#### **4.4.2 Seasonal index of major pulse crops in Madhya Pradesh**

##### **Seasonal index of Gram crop in Madhya Pradesh**

Normally, gram is grown in rabi season in Madhya Pradesh. The seasonal price and arrival indices of gram are presented in the Table 4.92 and figure 4.58. It was observed from the table that highest arrival index of gram was observed in the months of March (288.96) in KUMS, Dewas. The decline in the arrivals was more prominent from April to November and reached to the lowest in November (18.91) in

KUMS, Dewas. The arrivals indices of gram were more than 100 in the months of February to June in KUMS, Dewas.

In respect to price index of gram, the lowest seasonal price index value was observed in the month of March (76.52) in KUMS, Dewas of Madhya Pradesh. The maximum gram crop was harvested in March – April months. In KUMS, Dewas, the peak value of seasonal price index was observed in the month of November (136.12). The arrivals and prices indices of gram showed inverse relationship in the KUMS, Dewas. Throughout the study period, it was observed that more than 100 value of seasonal price indices of gram was found from August to December in KUMS, Dewas.

It was also notified from the figure that seasonal indices of arrival and prices showed inverse relationship in KUMS, Dewas. The small storage structures of farmers might be main cause of inverse relationship between arrivals and price in KUMS, Dewas. Similar findings were reported by Choudhary and Pawar (2010) in arrivals and prices of Chickpea from 1985-86 to 2004 -05 in Prabhani grain market of Maharashtra.

**Table 4.92: Seasonal indices of monthly arrivals and prices of Gram crop in KUMS, Dewas-Madhya Pradesh (2008-2017)**

(Arrivals and Price in Index)

S.No.	Month	Arrivals	Price
1	January	40.16	92.79
2	February	115.12	87.05
3	March	<b>288.96</b>	<b>76.52</b>
4	April	256.39	76.85
5	May	157.26	85.18
6	Jun	110.05	90.80
7	July	58.15	97.20
8	August	45.43	103.93
9	September	34.38	107.76
10	October	44.06	131.23
11	November	<b>18.91</b>	<b>136.12</b>
12	December	31.12	114.57
<b>Total</b>		<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

### Seasonal index of Lentil crop in Madhya Pradesh

During study period (2008-2017), the seasonal indices of arrivals and prices of lentil in KUMS, Gorakhpur are shown in Table 4.93 and figure 4.59. It was revealed from the table that highest arrival index of lentil was recorded in the month of April (200.51) in KUMS, Gorakhpur. In the mean time, the lowest arrival indices of lentil was found in the month of November (42.36) in KUMS, Gorakhpur. The arrival index of lentil was recorded more than 100 from March to August months in KUMS, Gorakhpur. Thus, the arrivals of lentil showed a definite pattern, depicting fluctuation in systematic manner.

The highest and lowest seasonal price indices of lentil was found in the month of November (126.25) and April (80.77), respectively, in KUMS Gorakhpur. More than 100 seasonal price indices of lentil were recorded from June to November in the selected market. It showed a definite pattern of seasonality in price according to crop season. It could be concluded from the findings that arrivals of lentil was having negative relation with the price.

**Table 4.93: Seasonal indices of monthly arrivals and prices of Lentil crop in KUMS, Gorakhpur (2008-2017)**

(Arrivals and Price in Index)

S.No.	Month	Arrivals	Wholesale Price
1	January	60.09	91.82
2	February	55.48	88.84
3	March	116.40	88.19
4	April	<b>200.51</b>	<b>80.77</b>
5	May	167.06	98.92
6	Jun	134.80	100.54
7	July	130.09	105.94
8	August	107.98	104.12
9	September	72.47	105.97
10	October	56.26	111.00
11	November	<b>42.36</b>	<b>126.25</b>
12	December	56.50	97.64
<b>Total</b>		<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

Therefore, it could be analyzed from the table that there is inverse relationship between price and arrivals of lentil in the KUMS, Gorakhpur. It might be due to distress sale of gram growers in KUMS, Gorakhpur. Similar findings were reported by Asmatoddin *et al.* (2009) in arrivals and prices of gram from 1996-97 to 2004-05 in Prabhani market of Maharashtra.

### Seasonal index of Black gram crop in Madhya Pradesh

Throughout the India, black gram is cultivated in kharif season. The seasonal indices of arrivals and prices of black gram are depicted in Table 4.94 and figure 4.60. It was revealed from the table that KUMS, Ganjbasoda witnessed for the lowest arrivals indices during July (62.75) and highest in the month of November (147.31). The arrival indices of black gram were observed more than 100 from October to March except January month in KUMS, Ganjbasoda.

In the KUMS, Ganjbasoda, the highest seasonal price indices of black gram was found in the month of July (117.85) followed by June (110.78), August (108.95) September (107.33) and so on. During April to October, the seasonal price indices of black gram were recorded more than 100 in KUMS, Ganjbasoda.

**Table 4.94: Seasonal indices of monthly arrivals and prices of Black gram crop in KUMS, Ganjbasoda (2008-2017)**

(Arrivals and Price in Index)

S.No.	Month	Arrivals	Price
1	January	74.53	90.11
2	February	101.07	91.51
3	March	132.24	93.26
4	April	97.55	100.24
5	May	99.96	104.62
6	Jun	96.39	110.18
7	July	<b>62.75</b>	<b>117.85</b>
8	August	67.92	108.95
9	September	71.28	107.33
10	October	113.10	105.47
11	November	<b>147.31</b>	<b>80.49</b>
12	December	135.90	90.01
<b>Total</b>		<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

Therefore, it could be analyzed from the table that there was contrary relationship between price and arrivals of black gram in the KUMS, Ganjbasoda. It might be due to poor storage infrastructure of farmers in the selected study area. Similar findings were reported by Prakesh *et al.* (1995) in arrivals and prices of urdbean in Uttar Pradesh.

### Seasonal index of Green gram crop in Madhya Pradesh

During study period (2008-2017), the seasonal indices of arrivals and prices of green gram are presented in the Table 4.95 and figure 4.61. It was revealed from the table and figure that KUMS, Manawar was witnessed for highest arrival indices of green gram in the month of November (211.24) and lowest in the month of June (59.83). More than 100 arrival indices of green gram were observed from October to February in the KUMS, Manawar.

The highest and lowest seasonal price indices of Green gram were found in the month of June (113.16) and November (84.12), respectively in the KUMS, Manawar. The seasonal price indices of green gram in KUMS, Manawar were more than 100 from March to September months.

**Table 4.95: Seasonal indices of monthly arrivals and prices of Green gram crop in KUMS, Manawar (2008-2017)**

(Arrivals and Price in Index)

S.No.	Month	Arrivals	Wholesale Price
1	January	114.06	92.75
2	February	121.51	85.69
3	March	98.27	100.41
4	April	76.44	106.51
5	May	78.80	108.62
6	Jun	<b>59.83</b>	<b>113.16</b>
7	July	63.61	108.49
8	August	67.44	109.81
9	September	72.17	106.00
10	October	127.78	93.82
11	November	<b>211.24</b>	<b>84.12</b>
12	December	108.86	90.62
<b>Total</b>		<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

It could be concluded from the findings that arrivals and price indices of green gram have negative relationship in KUMS, Manawar. It might be due to marketed surplus more than marketable surplus of green gram in KUMS, Manawar. Similar findings were reported by Sharma (2014) in arrivals and prices of barley from 2002-2012 in Jaipur market of Rajasthan.

### **Seasonal index of pigeon pea crop in Madhya Pradesh**

The seasonal indices of arrivals and prices of pigeon pea are presented in the Table 4.96 and figure 4.62. It was observed from the table that highest seasonal arrival index of pigeon pea was recorded in the month of January (168.31) followed by February (135.04) and October (120.50) in KUMS, Chhindwara. The seasonal arrival indices of pigeon pea were more than 100 during the months October to April in KUMS, Chhindwara. Higher indices of market arrivals of pigeon pea were noticed immediately after harvest in the selected market. The lowest arrival index of pigeon pea was observed in the month of July (57.68) in the KUMS, Chhindwara.

The value of the highest seasonal price indices of pigeon pea was found in the month of July (111.85) and lowest during January (84.67) months in KUMS, Chhindwara. The seasonal price index of pigeon pea in selected market were more than 100 during the months of March to August and less than 100 during the month of September to February.

Therefore, it could be analyzed from the analysis that there was inverse relationship between price and arrivals of pigeon pea in the KUMS, Chhindwara. It might be due to lack of storage facility of pigeon pea in Madhya Pradesh. Similar findings were reported by Newadkar *et al.* (1992) in arrivals and prices of tur from 1971-21 to 1990-91 in Pune regulated market of Maharashtra. The price movement also demonstrates significant seasonal fluctuations in the selected markets. As a short term fluctuations, one will notice a general finding that the price is low when the arrivals were large and the price being high when the arrivals were low.

**Table 4.96: Seasonal indices of monthly arrivals and prices of Pigeon pea crop in KUMS, Chhindwara (2008-2017)**

(Arrivals and Price in Index)

S. No.	Month	Arrivals	Price
1	January	<b>168.31</b>	<b>84.67</b>
2	February	135.04	96.63
3	March	108.57	103.20
4	April	103.62	106.56
5	May	67.28	110.06
6	Jun	64.54	107.64
7	July	<b>57.68</b>	<b>111.85</b>
8	August	66.50	106.71
9	September	91.12	95.06
10	October	120.50	89.52
11	November	100.74	94.07
12	December	116.11	94.04
<b>Total</b>		<b>1200</b>	<b>1200</b>

Source: Author's own commutation from compiled time series data.

### **Intra-year price variation in selected pulse crops**

The extents of seasonal price variation were determined by using different measures of intra year price variations. The three methods to measure the intra-year price variations used in this study were the intra-year price rise (IPR), coefficient of average seasonal price variation (ASPV) and the coefficient of variation (CV). With a view to ascertain difference in the magnitude of the seasonal variations in the pulse crops, the analysis was carried out in terms of IPR, ASPV and C.V. For this purpose, the magnitude of fluctuations in seasonal indices of all the five pulse crops namely gram, green gram, black gram, lentil and pigeon pea were measured with the help of the coefficient of average seasonal price index variation. The results obtained are presented in Table 4.97 and Table 4.98.

### **Coefficients of average seasonal variation in Rajasthan**

The IPR, ASVP and CV of prices of selected pulse crops in Rajasthan are presented in the Table 4.97. It was revealed from the table that the difference between lowest and highest intra-year price rise ranged between 29.56 per cent in KUMS,

Bikaner for gram to 66.06 per cent in KUMS, Bundi for lentil. The highest coefficient of average seasonal price variation (ASPV) was recorded in KUMS, Kekari (88.56%) in green gram and the lowest in KUMS, Bundi (77.86%) in lentil crop. The maximum value of coefficient of variation for lentil was observed in KUMS, Bundi (17.07%), followed by black gram (12.65%) in KUMS, Bundi; pigeon pea (11.94% ) in KUMS, Pratapgarh and green gram (10.49%) in KUMS, Kekari. The minimum value of CV was recorded for gram (8.71) % in KUMS, Bikaner. The lentil crop was instable in terms of prices whereas gram crop was observed relatively more stability in the selected KUMS, Bikaner. As the coefficient of variation increased, the degree of stability of prices decreased. Similar findings were reported by Agrawal and Sharma (1990) in inter-year and intra-year price fluctuation of pulse crops from 1974-75 to 1989-90 in Rajasthan.

**Table 4.97: Coefficient of Average Seasonal Price Variation of Selected Pulse Crops of Rajasthan (2008 to 2017)**

Crop	Market	Magnitude of Variation		
		IPR	ASPV	C.V.
Gram	Bikaner	29.56	84.90	8.71
Lentil	Bundi	66.06	77.86	17.07
Black gram	Bundi	51.21	78.98	12.65
Green gram	Kekari	32.18	88.56	10.49
Pigeon pea	Pratapgarh	41.49	81.89	11.94

Source: Author's own commutation from compiled time series data.

#### **Coefficients of average seasonal variation in Madhya Pradesh**

The IPR, ASVP and CV of prices of selected pulse crops in Madhya Pradesh are presented in the Table 4.98. It was revealed from the table that the difference between lowest and highest intra-year price rise ranged between 32.10 per cent in KUMS, Chhindwara for pigeon pea to 77.89 per cent in KUMS, Dewas for gram. The highest coefficient of average seasonal price variation (ASPV) was recorded in KUMS, Chhindwara (84.67%) in pigeon pea and the lowest in KUMS, Dewas (76.52%) in gram crop. Maximum value of the coefficient of variation for gram was observed in KUMS, Dewas (19.51 %), followed by lentil (12.08 % in KUMS,

Gorakhpur), black gram (10.82 % in KUMS, Ganjbasoda) and green gram (10.14 % in KUMS, Manawar) and minimum for pigeon pea (8.71 % in KUMS, Chhindwara). Gram was instable in terms of prices whereas pigeon pea crop observed relatively more stability in the selected KUMS.

**Table 4.98: Coefficient of Average Seasonal Price Variation of Selected Pulse Crops of Madhya Pradesh (2008 to 2017)**

Crop	Market	Magnitude of Variation		
		IPR	ASPV	C.V. for prices
Gram	Dewas	77.89	76.52	19.51
Lentil	Gorakhpur	56.31	80.77	12.08
Black gram	Ganjbasoda	46.43	80.49	10.82
Green gram	Manawar	30.54	84.12	10.14
Pigeon pea	Chhindwara	32.10	84.67	8.79

Source: Author's own commutation from compiled time series data.

As the coefficient of variation increased, the degree of stability of prices decreased. The variability in fresh arrivals, stock of the products in market and the demand affects the price to a great extent. Keeping such variations in demand in view, the growers can obtain better prices by matching supply to the market requirements during the period of high seasonal price index. Similar findings were reported by Agrawal and Sharma (1990) in inter year and intra year price fluctuation of pulse crops from 1974-75 to 1989-90 in Rajasthan.



## 5. SUMMARY AND CONCLUSIONS

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### 5.1 Introduction

India is nucleus of pulses in the world. Almost all types of pulse crops are grown in India. Therefore, India has been sustaining its top position around the world in pulse production. The global pulse production is estimated to be around 60 million tonnes out of 90 (Vision 2050) countries. India produced 25.23 million tonnes in 2017-18 which is the largest production around the world. Not only largest producer but India is largest consumer, processor and importer of pulses. India imported around 3 to 4 million tonnes of pulses in 2017-18 to meet out its domestic demand. The per capita availability of pulses has been declining, resulting price escalation and food inflation. The reason of unmet demand is supply bottlenecks. Though India is the largest producer of pulses but it is lagging behind the average world pulse productivity ( $650 \text{ kg}^{-1}$ ). Pulses have been constant source of food inflation over the past two decades. The anomaly can be corrected if we are able to increase domestic productivity by incentivizing technological adoption, expanding the area under irrigation and the adoption of improved varieties. It is very challenging to overcome the demand scenario with poor productivity level and stagnant production. Pulses production in the country was stagnant between 15 and 25.23 million tonnes with significant growth between 2010-11 and 2017-18. Even after producing the highest quantity of pulses, import would become necessary to bridge the gap between demand and supply. The growth rate of pulses production was stagnant as compared to population growth rate of 1.44 per cent and has led to progressive decline in per capita availability of pulses.

The arrivals of pulses in the market are not uniform throughout the year. Generally, arrivals are more in the production season in the producing areas and lesser in the other seasons. Pulses market arrivals and prices exhibit a seasonal pattern. The season based production causes fluctuations in prices from one season to the other. The fluctuation in prices causes wide variation in the income of pulses growers from season to season and year to year. In this context the present study entitled “Dynamics of area and production of major pulse crops in India” was carried out with following objectives:

1. To estimate the trend in area, production and productivity of pulse crops in India.
2. To estimate the relative contribution of acreage and yield in production of pulse crops over time.
3. To measure instability in area, production and productivity and to determine the causes of instability, and
4. To analyze the seasonal price behavior of major pulse crops.

## **5.2 Material and Methods**

In the present study information available through secondary sources has been used. Time series data were procured from Directorate of Economics and Statistics, Ministry of Agriculture, Indiatat.com, AGMARK and NAFED and Krishi Upaj Mandi Samities, etc.

The present study makes use of 30 years time series data (1988-89 to 2017-18) for the analysis of growth, trend, decomposition and instability whereas growth and decomposition were calculated period wise as period-I (1988-89 to 1997-98 ), period-II (1998-99 to 2007-08), period-III (2008-89 to 2017-18) and overall period (1988-89 to 2017-18). For the first objective, time series data on area, production and productivity of major pulse crops viz., gram, lentil, black gram, green gram and pigeon pea in major producing states viz., Rajasthan, Madhya Pradesh, Uttar Pradesh, Maharashtra and Karnataka were used. Compound growth rate in area, production and productivity, log linear form of equations (also known as exponential function) were used to estimate. Linear, quadratic and exponential functions were used to estimate trend pattern in area production and productivity of selected pulse crops in selected states. The function which has the highest coefficient of determination among above three functions was selected for further explanation. The same data were used for decomposition analysis to achieve second objectives as well as for measurement of instability in area, production and productivity. The coefficient of variation for instability analysis was computed by Cuddy Della Valle Index. Beside decomposition of production growth, the production variability in major states of India for major pulse crops was also computed. Acreage response function using lagged area of main crop, area and lagged area of major competitive crop for each selected pulse crops, seasonal rainfall, and lagged seasonal rainfall were estimated for determining the

causes of instability in major pulse crops of selected states in India. Similarly, yield response function with productivity, time, seasonal rainfall and lagged seasonal rainfall were estimated to identify the causes of yield in major pulse crops of selected states of India. The fourth objective was based on seasonal variation of selected pulse crops in Rajasthan and Madhya Pradesh. Ten years (January, 2008 to December 2017) monthly time series data on arrivals and wholesale prices were collected to estimate the seasonal variation of selected pulse crops in Rajasthan and Madhya Pradesh. The moving average method was used to estimate the seasonal index.

### **5.3 Results and Discussion**

The findings of the study are summarized objective - wise in the following section:

#### **5.3.1 Compound growth rates**

##### **5.3.1.1 Compound growth rates of major pulses in Rajasthan**

There has been positive and significant growth in productivity of gram during overall period (1988-89 to 2017-18) and period-III (2008-09 to 2017-18) at the rate of 2.33 and 7.89 per cent per annum, respectively. During period-I (1988-89 to 1997-98) growth in area and production of gram in Rajasthan was significantly increased at the rate of 11.69 and 17.49 per cent per annum, respectively. There was negative and non significant growth in area, production and productivity of gram in Rajasthan during period-II. During overall period, the area and production of lentil recorded positive and significant growth rate in Rajasthan. In this period, the reported growth rate was 12.72 per cent in production followed by 11.94 per cent in area of lentil. In the period-I, the area, production and productivity of lentil were significantly augmented with the extent of 28.53, 40.93 and 9.40 per cent per annum, respectively. The period-I attributed significant and remarkable improvement in production of lentil; it could be due to positive and significant growth in productivity and area under this crop. Whereas, the production and productivity of lentil in period-II declined significantly at the rate of -26.72 and -8.80 per cent per year, respectively. During period-III, the highest and significant growth rate was recorded in production (39.96%) of lentil followed by area (38.36%) under this crop. During entire study period, the area, production and productivity of black gram were increased significantly at the rate of 5.20, 8.89 and 3.75 per cent per annum, respectively. In the period-I, the area of black

gram increased significantly at the rate of 8.89 per cent per annum. There was no significant growth found in area, production and productivity of black gram in Rajasthan during period-II. During period-III, the growth in all three aspects *viz.*, area, production and productivity of black gram was reported at the rate of 43.22, 62.93 and 14.02 per cent per annum respectively in the state. In the mean time, area and production of this crop notified remarkable and significant improvements in Rajasthan. The growth in area and production of green gram in Rajasthan increased significantly at the rate of 13.24 and 19.12 per cent per annum, respectively in the entire study period. During the period-I (1988-89 to 1997-98), the area under green gram increased significantly with annual growth rate of 21.34 per cent. During period-II, the highest and significant growth rate was found in production (65.20%) of green gram followed by productivity (37.40%) and area (20.50%) per annum. In the period-III, the area under green gram in the state was increased significantly at the rate of 15.88 per cent annum. During overall period, the area under pigeon pea declined significantly with annual growth rate of -3.17 per cent in Rajasthan. During same period, the production of this crop recorded positive and significant growth rate with the magnitude of 0.10 per cent per annum. During period-I and period-III, the results stated positive and non significant growth rate in all three aspects *viz.*, area, production and productivity of pigeon pea. The study period-II reported negative and significant growth rate in area of pigeon pea at the rate of -9.43 per cent per annum.

#### **5.3.1.1.2 Compound growth rates of major pulses in Madhya Pradesh**

Growth of area, production and productivity of gram in Madhya Pradesh increased significantly at the rate of 3.04, 6.41 and 3.51 per cent per year, respectively throughout the study period. In the period-I, the area, production and productivity under gram also increased significantly at the rate of 4.95, 12.98 and 7.65 per cent per annum, respectively. In study period-II, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of gram. During period-III (2008-09 to 2017-18), the area, production and productivity of gram in Madhya Pradesh was augmented significantly at the rate of 3.04, 8.14 and 5.20 per cent per annum, respectively. During overall period, the area, production and productivity of lentil in Madhya Pradesh was enlarged significantly at the annual rate of 4.47, 7.65 and 3.28 per cent, respectively. During period-I, Madhya Pradesh recorded significant growth rate in area and production of lentil at the rate of 12.98 and 13.24 per cent per

annum, respectively. However, the productivity of lentil reported -1.37 per cent per annum and significant growth rate in the state. In study period-II, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of lentil. In the study period-III, state production and productivity of lentil increased significantly at the rate of 27.35 and 26.47 per cent per annum. During entire study period, area, production and productivity of black gram were augmented significantly at the rate of 4.23, 9.65 and 5.68 per cent per annum, respectively. The area of black gram recorded negative and significant growth rate of -5.81 per cent per annum in the period-I. In study period-II, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of black gram. During period-III, growth rate in area, production and productivity of black gram observed remarkable significant growth rate of 35.52, 69.06 and 19.95 per cent per annum, respectively in Madhya Pradesh. The production and productivity of green gram was found positive and significant growth rate with the magnitude of 8.14 and 4.23 per cent per annum in the entire study period. In the period-I, area and production of green gram significantly decreased at the rate of -17.59 and -6.89 per cent, respectively. In the period-II, growth of area under green gram was negative (-6.89%) and significant. During period-III, growth rate in area, production and productivity of green gram recorded significant growth at the rate of 62.93, 97.24 and 21.06 per cent, respectively. The growth of area under pigeon pea was significantly increased with magnitude of 2.57 per cent in overall study period. In the period-I, area, production and productivity of pigeon pea decreased significantly at the rate of -5.81, 14.89 and -9.22 per cent per annum, respectively in the state. In study period-II, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of pigeon pea. During period-III, the area, production and productivity of pigeon pea increased significantly at the rate of 17.22, 41.58 and 20.78 per cent, respectively in Madhya Pradesh.

#### **5.3.1.1.3 Compound growth rates of major pulses in Uttar Pradesh**

The growth of area and production of gram crop were found negative and significant at the rate of -7.74 and -7.32 per cent in entire study period. In the period-I, area and production of gram were decreased significantly at the rate of -10.05 and -9.64 per cent, respectively. In the period-II, significant growth was seen in area and production of gram at the rate of 11.17 and -13.50 per cent, respectively. During

period-III, the area, production and productivity of gram in the state was declined significantly the rate of -4.94, -6.46 and -0.69 per cent, respectively. During entire study period, the area, production and productivity of lentil were decreased non-significantly at the rate of -0.46, -0.69 and -0.0026 per cent per annum, respectively. During this period, the production of lentil was declined in Uttar Pradesh; it may be due to negative growth in area and productivity of lentil crop. In the first period, area, production and productivity of lentil were also declined non-significantly at the rate of -0.46, -1.09 and -0.69 per cent, respectively in the state. In the same way, area, production and productivity of lentil were also represented negative and non-significantly growth at the rate of -1.14, -1.37 and -0.23 per cent, respectively in second period. In case of period-III, the area and production of lentil were declined significantly at -7.10 and -11.08 per cent per annum, respectively in the state. At the same time, productivity under lentil was also decreased non-significantly with -3.84 per cent annually. During entire study period, area, production and productivity of black gram significantly increased at the rate of 10.41, 14.82 and 3.75 per cent per annum, respectively. In the period-I, area, production and productivity of black gram increased significantly at the rate of 6.41, 14.82 and 7.89 per cent, respectively. In the period-II, area and production of black gram were augmented significantly with 12.72 and 22.46 per cent, respectively. During period-III, area under black gram increased significantly at the rate of 9.65 per cent per annum. During entire study period, the area, production and productivity of green gram significantly increased at 13.76, 22.18 and 7.40 per cent per annum, respectively. In the period-I, area and production under green gram significantly increased at 9.40 and 15.61 per cent per annum, respectively. In the second period, area under green gram increased significantly at 7.89 per cent per annum. During third period in the state, the area and production of green gram was enlarged significantly at 24.74 and 34.59 per cent, respectively. Throughout study period, the area, production and productivity of pigeon pea significantly decreased at -5.16, -7.96 and -2.95 per cent per annum, respectively in Uttar Pradesh. The production of pigeon pea in first period declined significantly with the magnitude of -5.81 per cent. On the contrary, productivity of pigeon pea was enhanced significantly at the rate of 5.68 per cent per annum. In second period, production and productivity of pigeon pea were declined significantly at the rate of -12.70 and -10.46 per cent, respectively. In study period-III, the results stated non

significant growth rate in all three aspects *viz.*, area, production and productivity of pigeon pea.

#### **5.3.1.1.4 Compound growth rates of major pulses in Maharashtra**

During overall period, the area, production and productivity of gram in Maharashtra were augmented significantly at the rate of 9.65, 13.76 and 3.75 per cent, respectively. In study period-I, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of gram. In second period, the area, production and productivity of gram recorded significant growth rate of 12.46, 19.40 and 6.41 per cent per annum, respectively. In third period, the area under gram was mounted up significantly at 13.76 per cent in the state. During entire study period, area under lentil decreased significantly at the rate of -5.38 per cent per annum in Maharashtra. In study period-I, period-II and period-III, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of lentil. During entire study period, area under black gram decreased significantly at the rate of -2.95 per cent. In the period-I, area was increased significantly at the rate of 7.15 per cent per annum. In study period-II, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of black gram. During period-III, productivity of this crop reported significant growth at the rate with 15.35 per cent per annum in the state. During entire study period, production of green gram declined significantly at the rate of -0.92 per cent. During period-I, negative and significant growth rate was seen in area (-5.16%) of green gram in Maharashtra. In study period-II and III, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of green gram. During entire study period, area, production and productivity of pigeon pea increased significantly at the rate of 2.33, 5.44 and 3.04 per cent, respectively. During first period, area under pigeon pea was reported affirmative and significant growth rate of 2.80 per cent per annum. In the period-II, area and production of pigeon pea significantly increased at 3.04 and 3.51 per cent, respectively. In the period-III, area increased significantly at the rate of 4.71 per cent per annum.

#### **5.3.1.1.5 Compound growth rates of major pulses in Karnataka**

Throughout study period, the area, production and productivity of gram significantly increased at 11.17, 18.30 and 4.71 per cent, respectively in Karnataka.

During first period, area, production and productivity of gram increased significantly at the rate of 18.85, 31.52 and 10.66 per cent, respectively. In the period-II, area and production under gram increased significantly at the rate of 15.08 and 11.69 per cent, respectively. In study period III, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of gram. In study period-II, III and overall period the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of black gram in Karnataka. In the period-I, area and production of black gram increased significantly at the rate of 19.12 and 17.76 per cent, respectively. During overall period affirmative and significant growth rate was seen in area of green gram in Karnataka with 3.99 per cent. During first period, the production and productivity of green gram declined significantly at -22.73 and -21.66 per cent, respectively. In study period-II, III and overall period, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of green gram. During entire study period, area, production and productivity of pigeon pea significantly increased at the rate of 6.41 per cent, 12.72 per cent and 5.93 per cent per annum respectively. In study period-I, the results stated non significant growth rate in all three aspects *viz.*, area, production and productivity of pigeon pea. During period-II, area and production of pigeon pea significantly increased at the rate of 7.15 and 16.95 per cent, respectively. In the period-III, area and production under pigeon pea significantly increased at the rate of 10.15 per cent and 20.23 per cent, respectively.

### **5.3.1.1 Trend in area, production and productivity of major pulse crops in India**

#### **5.3.1.1.1 Trend analysis of major pulses in Rajasthan**

The estimated trend equation of production and productivity under gram presented that the value of b coefficient with magnitude of -0.352 and -12.697 respectively, with time period represented the negative linear relation and the value of c coefficient was found to be 0.014 and 0.671 respectively, with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in production and productivity. The effect of quadratic (c) coefficient was non-significant and positive which shows that the production and productivity of gram were increasing over the year. The estimated trend equation of area and production in lentil depicted that the value of b coefficient was found to be -0.016 and -0.009 respectively, with time period represented the negative linear relation and the

value of c coefficient was found to be 0.001 and 0.001 respectively, with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area and production. The effect of quadratic coefficient (c) was significant and positive which was implying that the area and production of lentil were increasing over the years. The estimated trend equation of area, production and productivity under black gram presented that the value of b coefficient with magnitude of -0.153, -0.121 and -16.345 respectively, with time period represented the negative linear relation and the value of c coefficient was found to be 0.007, 0.005 and 0.758 respectively, with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area, production and productivity. The effect of quadratic coefficient (c) was significant and positive which shows that the area, production and productivity of black gram were increasing over the year. The estimated trend equation of area under green gram presented that the value of b coefficient (0.040) with time period represented the positive linear relation and the value of c coefficient (0.011) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area over time in case of green gram. The effect of quadratic coefficient (c) was significant and positive. The estimated trend equation of production and productivity of green gram depicted that the value of b coefficient was found at the rate of -0.130 and -15.993 respectively, with time period represented downward linear relation and the value of c coefficient was found to be 0.011 and 0.746 respectively, represented the positive quadratic relation. Thus the effect of time period represented the curvature in production. The quadratic effect was positive and significant in green gram production. Hence the quadratic term was also positive implying that production and productivity of green gram were also increasing over the year.

#### **5.3.1.1.2 Trend of major pulses in Madhya Pradesh**

The estimated trend equation of area and productivity under gram depicted that the value of b coefficient was found to be 0.010 and 5.767, respectively, with time period represented the positive linear relation and the value of quadratic (c) coefficient was found to be 0.011 and 0.260, respectively with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive which shows that the area and productivity of gram were increasing over the

year. The estimated trend equation of production of gram depicted that the value of b coefficient (-0.060) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.024) with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in production. The quadratic (c) coefficient effect was positive and significant in gram production. The estimated trend equation of area under lentil depicted that the value of b coefficient was found to be 0.198 with time period represented the positive linear relation and the value of quadratic (c) coefficient (-0.004) with time period represented the negative quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and negative which was implying that the area of lentil was decreasing over the years. The estimated trend equation in production and productivity of lentil depicted that the value of b coefficient was found to be -0.078 and -30.005 with time period represented downward linear relation and the value of quadratic (c) coefficient was found to be 0.006 and 1.275 with time period represented the positive quadratic relation. Thus, the effect of time period represent the curvature in production. The quadratic (c) coefficient effect was positive and significant in lentil. The estimated trend equation of area, production and productivity under black gram represented that the value of b coefficient with magnitude of -0.666, -0.492 and -14.038 respectively, with time period represented the negative linear relation and the value of quadratic (c) coefficient was found to be 0.027, 0.021 and 0.779 respectively, with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area, production and productivity. The effect of quadratic (c) coefficient was significant and positive which shows that the area, production and productivity of black gram were increasing over the years. The estimated trend equation of area, production and productivity under green gram depicted that the value of b coefficient with magnitude of -0.261, -0.147 and -16.450 respectively, with time period represented the negative linear relation and the value of quadratic (c) coefficient was found to be 0.010, 0.006 and 0.766 respectively, with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area, production and productivity. The effect of quadratic (c) coefficient was significant and positive. The estimated trend equation of area, production and productivity under pigeon pea presented that the value of b coefficient with magnitude of -0.321, -0.593 and -66.117 respectively, with time period

represented the negative linear relation and the value of quadratic(c) coefficient was found to be 0.012, 0.021 and 2.063 respectively, with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area, production and productivity of pigeon pea. The effect of quadratic (c) coefficient was significant and positive.

#### **5.3.1.1.3 Trend of major pulses in Uttar Pradesh**

The estimated trend equation of area and production under gram depicted that the value of b coefficient was found to be -0.514 and -0.406 respectively, with time period represented the negative linear relation and the value of quadratic (c) coefficient was found to be 0.008 and 0.006 respectively, with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive. The estimated trend equation in productivity of gram depicted that the value of b coefficient was found to be 1.762 with time period represented increasing linear relation and the value of quadratic (c) coefficient was found to be 0.037 with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in productivity. The quadratic (c) coefficient effect was positive and significant in gram. The estimated trend equation of area, production and productivity under lentil presented that the value of b coefficient with magnitude of 0.187, 1.171 and 5.349 respectively, with time period represented the positive linear relation and the value of quadratic (c) coefficient was found to be -0.006, -0.006 and -0.164 respectively, with time period represented the negative quadratic relation. Thus, the effect of time period represented the curvature in area, production and productivity of lentil. The effect of quadratic (c) coefficient was significant and negative. The b value (0.043) was exponential in area, meaning curvilinear with increasing in many folds. The effect of exponential (b) coefficient was significant and positive which was implying that the area of black gram was increasing over the year in multiple of times. At the same time, b coefficient value (0.060) was exponential in black gram production; it means curvilinear with increasing trend. The exponential effect was significant in black gram production. Further, the positive exponential term was implying that black gram production was also mounting over the years. In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (4.605) with time period represented upward linear relation and the value

of quadratic (c) (0.091) with time period represented the positive quadratic relation. Thus, the quadratic coefficient effect of time period, represented the curvature in the productivity of black gram. The effect of quadratic (c) coefficient was non significant. The estimated trend equation of area, production and productivity under green gram depicted that the value of b coefficient with magnitude of -0.0.26, -0.0.20 and -8.412 respectively, with time period represented the negative linear relation and the value of quadratic (c) coefficient was found to be 0.002, 0.001 and 0.667 respectively, with time period represented the positive quadratic relation. Thus, the quadratic coefficient effect of time period represented the curvature in area, production and productivity of green gram. The effect of quadratic (c) coefficient was significant and positive. The estimated trend equation of area, production and productivity under pigeon pea presented that the value of b coefficient with magnitude of -0.0.099, -0.201 and -20.003 respectively, with time period represented the negative linear relation and the value of quadratic (c) coefficient was found to be 0.031, 0.002 and 0.252, respectively, with time period represented the positive quadratic relation. Thus, the quadratic (c) coefficient effect of time period represented the curvature in area, production and productivity of pigeon pea. The effect of quadratic (c) coefficient was non significant and positive.

#### **5.3.1.1.4 Trend of major pulses in Maharashtra**

The estimated trend equation of area and production under gram depicted that the value of b coefficient was found to be -0.089 and -0.151 respectively with time period represented the negative linear relation and the value of quadratic (c) coefficient was found to be 0.016 and 0.018 respectively, with time period represented the positive quadratic relation. Thus, the quadratic (c) coefficient effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive. The estimated trend equation in productivity of gram depicted that the value of b coefficient at the rate of 0.983 with time period represented increasing linear relation and the value of quadratic (c) coefficient at the rate of 0.327 with time period represented the positive quadratic relation. Thus, the quadratic (c) coefficient effect of time period represented the curvature in production. The quadratic (c) coefficient effect was positive and non significant in gram. The estimated trend equation of area and production under black gram depicted that the value of b coefficient with magnitude of 0.253 and 0.157 respectively, with time

period represented the positive linear relation and the value of quadratic (c) coefficient was found to be -0.001 and -0.006 respectively, with time period represented the negative quadratic relation. Thus, the effect of time period represented the curvature in area and production. The effect of quadratic (c) coefficient was significant and negative which was implying that the area and production of black gram were decreasing over the years. The estimated trend equation of area under green gram depicted that the value of b coefficient was found to be -0.035 with time period represented the negative linear relation and the value of quadratic (c) coefficient was found -0.003, with time period represented the negative quadratic relation. The effect of quadratic (c) coefficient was significant and negative. The estimated trend equation in production of green gram depicted that the value of b coefficient was found to be 0.026 with time period represented increasing linear relation and the value of quadratic (c) coefficient was found to be -0.003 with time period represented the negative quadratic relation. Thus the quadratic (c) coefficient effect of time period represented the curvature in production. The quadratic (c) coefficient effect was negative and non significant in green gram. The estimated trend equation of area and production under pigeon pea depicted that the value of b coefficient were found 0.015 and 0.094 respectively with time period represented the positive linear relation and the value of quadratic (c) coefficient were found 0.003 and 0.003 respectively, with time period represented the positive quadratic relation. Thus, the quadratic (c) coefficient effect of time period represented the curvature in area and production. The effect of quadratic (c) coefficient was significant and positive.

#### **5.3.1.1.5 Trend of major pulses in Karnataka**

In the model, the b coefficient value (0.046) was exponential in area, showing curvilinear with increasing trend in many folds. The effect of exponential (b) coefficient term was positive and significant which was implying that the area of gram was increasing over the year in multiple of times in the state. At the same time, in the best-fit model, the b coefficient value (0.073) was exponential in gram production; it means curvilinear with increasing trend. The exponential effect in the production of gram was significant and the exponential term was also positive, it means production of gram was also increasing over the year in Karnataka. In case of productivity, the estimated trend equation of productivity depicted that the value of b coefficient (21.715) with time period represented upward linear relation and the value

of quadratic (c) coefficient (-0.383) with time period represented the negative quadratic relation. Thus the effect of time period, represented the curvature in the productivity of gram. The effect of quadratic (c) coefficient was non significant. The estimated trend equation of area under black gram depicted that the value of b coefficient were found 0.077 with time period represented the positive linear relation and the value of quadratic (c) coefficient were found -0.002 with time period represented the positive quadratic relation. Thus, the quadratic (c) coefficient effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and negative. The estimated trend equation of area revealed that the value of b coefficient (0.178) with time period represented the positive linear relation and the value of quadratic (c) coefficient (-0.004) with time period represented the negative quadratic relation. Thus, the quadratic (c) coefficient effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was non significant and negative. In case of productivity, the estimated trend equation of green gram depicted that the value of b coefficient (-28.920) with time period represented downward linear relation and the value of quadratic (c) coefficient (0.718) with time period represented the positive quadratic relation. Thus the effect of time period, represented the curvature in the productivity of green gram. The effect of quadratic (c) coefficient was significant. The estimated trend equation of area and production under pigeon pea depicted that the value of b coefficient was found to be -0.098 and -0.072 respectively with time period represented the negative linear relation and the value of quadratic (c) coefficient was found to be 0.009 and 0.008 respectively, with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in area. The effect of quadratic (c) coefficient was significant and positive. The estimated trend equation in productivity of pigeon pea depicted that the value of b coefficient was found to be 8.105 with time period represented increasing linear relation and the value of quadratic (c) coefficient was found to be 0.126 with time period represented the positive quadratic relation. Thus, the effect of time period represented the curvature in production. The quadratic (c) coefficient effect was positive and non significant in pigeon pea.

### **5.3.2 Decomposition of production growth for individual pulse crop**

#### **5.3.2.1 Decomposition of pulses production in Rajasthan**

The data on analysis revealed that area effect was prime contributor in period-I and II but in case of period-III and overall, interaction effect was the major contributor to increase the production of gram in Rajasthan. During period-I, II, III and overall period, area effect was mainly responsible for increase in production of lentil. The break - up of the increase in black gram production into its components revealed that area was the major factor in increasing production in the state except period-II. During period-II, yield effect was more dominant than area and their interaction to produce the black gram. Area effect was prime contributor in period-I and III but in case of period-II and overall, interaction effect was major contributor to increase the production of green gram. Interaction effect was prime contributor in period-I and overall period of pigeon pea. During period-II, yield effect was more dominant but in case of period-III, area effect was major contributor to increase the production of pigeon pea in Rajasthan.

#### **5.3.2.2 Decomposition of pulses production in Madhya Pradesh**

From the analysis it was seen that interaction effect was the prime contributor in period-II, III and overall periods but in case of period-I yield effect was major contributor to increase the production of gram in Madhya Pradesh. Area effect was prime contributor in period-I and II but in case of period-III and overall periods, yield effect was major contributor to increase the production of lentil. During period-I, II, III and overall periods, area effect was mainly responsible for increase in production of black gram. Area effect was prime contributor in period-I and II but in case of period-III and overall periods, yield effect was major contributor to increase the production of green gram. Area effect was prime contributor in period-II and overall but in case of period-I and period-III, yield effect was major contributor to increase the production of pigeon pea in Madhya Pradesh.

#### **5.3.2.3 Decomposition of production growth in Uttar Pradesh**

On analyzing the data it was found that area effect was prime contributor to increase the production of gram in period-I and overall periods. During period-II, area effect was major contributor in increasing the production of gram in Uttar Pradesh, in case of period-III, interaction effect was mainly responsible for increase in production

of gram. Area effect was major contributor to increase production of lentil in period-I and overall period. During period-II interaction effect was also major contributor for increase in the production of lentil, in case of period-III yield effect was mainly responsible for increase in production of lentil. Area effect was more dominant to produce output of black gram in period-I, III and overall periods. During period-II yield effect was major contributor towards increase in the production of black gram. General interaction effect was responsible for an increase in production of green gram in Uttar Pradesh during period-II, III and overall periods, while area effect was responsible in period-I for increase in production of green gram. The growth in production of pigeon pea was achieved mainly due to expansion of acreage during overall period. Yield effect was more powerful for increase in output of pigeon pea in period-I, II and III.

#### **5.3.2.4 Decomposition of production growth in Maharashtra**

Considering the data collected for all five crops in Maharashtra, it was found that the growth in gram production was mainly due to area and interaction effect during overall period. In the period-I, yield effect was the most powerful element to increase in production of gram while area effect was the major factor in increasing production of gram during period-II and period- III. The area effect was responsible for increase in production of lentil during period-I and overall periods. During period-II interaction effect was more dominant to bring change in output of lentil while yield effect was more responsible to boost up the production of lentil during period-III. The growth in black gram production was mainly due to interaction and yield effect during overall periods. During period-I area effect and interaction effect were the major factors in increasing production of black gram. In the period-II and III yield effect was the most powerful element to increase the production of black gram. During overall periods the contribution of area effect (152.90%) to production growth of green gram in the state was the highest followed by yield effect (73.80%) and then interaction effect on production was negative (-126.70%). The growth in production was achieved through area and interaction effect of green gram during period-I and overall period. During period-II only yield effect was responsible to improve the production of green gram in Maharashtra while interaction effect and yield effect were also responsible for growth in production of green gram during period-III. The

growth in output of pigeon pea was mainly because of increase in yield of this crop in all the periods under study.

#### **5.3.2.5 Decomposition of production growth in Karnataka**

The increase in output of gram in Karnataka was mainly because of increase in area of this crop in all the periods under study. The area effect was more dominant factor in period-I and overall periods while yield effect was more powerful factor to increase in production of black gram during period-II and III. The interaction effect was most powerful factor to boost up the production of green gram in Karnataka during overall period. During period-I and III, yield effect was dominant factor to increase in production of output of green gram. During period-II, area effect was mainly responsible to increase in production of green gram. The interaction effect was most powerful factor to boost up the production of pigeon pea in Karnataka during period-III and overall period. During period-I, area effect was dominant factor to increase in production of pigeon pea. During period-II, yield effect was mainly responsible to increase in production of pigeon pea.

### **5.3.3 Analysis of instability and causes of instability of the major pulse crops**

#### **5.3.3.1 Instability analysis of major pulse crops**

##### **5.3.3.1.1 Instability analysis of major pulse crops in Rajasthan**

On analysis of the data it was revealed that area and production of selected pulse crops were highly instable in Rajasthan except area under green gram. Subsequently, the productivity of green gram and pigeon pea were also more instable while gram and black gram were found to be medium instable. In the mean time productivity of lentil was very less instable.

##### **5.3.3.1.2 Instability analysis of major pulse crops in Madhya Pradesh**

The data on analysis revealed that production of black gram and green gram were highly instable and area of green gram was also highly instable, while production of gram, lentil and pigeon pea were medium instable in Madhya Pradesh. In case of area of gram, lentil and pigeon pea were less instable and black gram was medium instable. In the mean time, productivity of lentil, black gram, green gram and pigeon pea were medium instable while productivity of gram was less instable.

#### **5.3.3.1.3 Instability analysis of major pulse crops in Uttar Pradesh**

It was seen that production of green gram was highly instable and production of gram and black gram were medium instable while lentil and pigeon pea were less instable in Uttar Pradesh. In case of area, gram, lentil, black gram and pigeon pea were less instable and green gram was medium instable. In the mean time, productivity of black gram and green gram were medium instable while productivity of gram, lentil and pigeon pea were less instable.

#### **5.3.3.1.4 Instability analysis of major pulse crops in Maharashtra**

The data of area production and productivity of lentil revealed that production of lentil, black gram and green gram were highly instable and production of gram and pigeon pea were medium instable in Maharashtra. In case of area, pigeon pea and green gram were very less instable while gram, lentil, black gram and green gram were medium instable. In the mean time productivity of selected crops were medium instable.

#### **5.3.3.1.5 Instability analysis of major pulse crops in Karnataka**

It was found that production of selected crops was highly instable in Karnataka. In case of area, gram was highly instable and black gram was less instable while green gram and pigeon pea were medium instable. In the mean time, productivity of gram and pigeon pea were medium instable while productivity of black gram and green gram were highly instable.

### **5.3.3.2 Causes of instability in acreage of selected pulse crops**

#### **5.3.3.2.1 Causes of instability in acreage of selected pulse crops in Rajasthan**

Considering the data collected for all the five crops in Rajasthan it was found that gram growers showed contrary response to lagged area under its competing crop i.e. the decrease in area of competing crop in last year season, led to increase the area under gram in Rajasthan. It was found that lentil growers in Rajasthan were quite responsive to lagged area under lentil crop. It means the increase in area of lentil in last year season, showed a tendency to increase the area under lentil. Black gram growers were quite responsive to lagged area of its competing crop. It means with the decrease in area of competing crop ( $C_t$  and  $C_{t-1}$ ), there was a tendency to increase the area under black gram in Rajasthan. Green gram growers were negatively responsive

to lagged area under this crop. It means with the decrease in area of its competing crop in last year season, there was tendency to increase the area under green gram in the state. pigeon pea growers were directly associated to lagged area under pigeon pea crop. It means when the area of pigeon pea in last year season was increased, then the area under pigeon pea also increased in Rajasthan during in current season.

#### **5.3.3.2.2 Causes of instability in acreage of selected pulse crops in Madhya Pradesh**

Chickpea growers in Madhya Pradesh showed contrary response to lagged area under its competing crop i.e. the decrease in area of competing crop in last year season, showed tendency to increase the area under gram. Again from the findings of lentil growers it was seen that the growers were quite responsive to lagged area under lentil crop. It means the increase in area of lentil in last year season revealed that there was a tendency to increase the area under lentil in successive year. Black gram growers in Madhya Pradesh were quite responsive to lagged area under black gram crop. It means that the increase in area of black gram in last year season, showed a tendency to increase the area under black gram. It was also observed from the findings that green gram growers were negatively responsive to lagged area under green gram crop. This signifies that the decrease in area of its competing crop in last year season; there was tendency to increase the area under green gram in the state. Finally the pigeon pea growers in Madhya Pradesh were found to be directly associated with lagged area under pigeon pea crop. It means that when the area of pigeon pea during last year season was increased, then the area under pigeon pea also increased in the current year.

#### **5.3.3.2.3 Causes of instability in acreage of selected pulse crops in Uttar Pradesh**

It was found that gram growers in Uttar Pradesh were quite responsive to lagged area of its competing crop. It means that with the decrease in area of competing crop ( $C_t$  and  $C_{t-1}$ ), there was a tendency to increase the area under gram. It was observed from the findings that lentil growers were directly associated to lagged area under lentil crop. It means when the area of lentil in last year season was increased, the area under lentil also increased. Again from the findings of black gram growers, it was seen that growers were quite responsive to lagged area under black gram crop. Green gram growers were negatively responsive to lagged area under this

crop. It means the decrease in area of its competing crop in last year season, there was a tendency to increase the area under green gram in the state. Finally the pigeon pea growers were quite responsive to lagged area of its competing crop. It means with the decrease in area of competing crop ( $C_t$  and  $C_{t-1}$ ), there was a tendency to increase the area under pigeon pea in Uttar Pradesh.

#### **5.3.3.2.4 Causes of instability in acreage of selected pulse crops in Maharashtra**

On analyzing the data of chickpea growers in Maharashtra, it showed contrary response to lagged area under its competing crop i.e. with the decrease in area of competing crop in last year season, there was an increase in the area under gram. Lentil growers were quite responsive to lagged area under lentil crop. It means the increase in lagged area of lentil in last year season led to increase in the area under lentil in Maharashtra. Black gram growers were negatively responsive to lagged area under this crop. It means the decrease in area of its competing crop in last year season, led to increase in the area under black gram in the state. Green gram growers were quite responsive to lagged area of its competing crop. It means the decrease in area of competing crop ( $C_t$  and  $C_{t-1}$ ), resulted in the increase in the area under green gram. Pigeon growers were quite responsive to lagged area under pigeon pea crop. It means the increase in area of pigeon pea in last year season; there was a tendency to increase the area under pigeon pea in Maharashtra.

#### **5.3.3.2.5 Causes of instability in acreage of selected pulse crops in Karnataka**

The data on analysis revealed that gram growers in Karnataka were quite responsive to lagged area of its competing crop. It means that with the decrease in area of competing crop ( $C_{t-1}$ ), there was a tendency to increase the area under gram. Black gram growers were quite responsive to lagged area under black gram crop. It means that with the increase in area of black gram in last year season, there was a tendency to increase the area under black gram. Green gram growers were negatively responsive to lagged area under this crop. It means that with the decrease in area of its competing crop in last year season, there was a tendency to increase the area under green gram in the state. Pigeon pea growers in Karnataka were quite responsive to lagged area of its competing crop. It means that with the decrease in area of competing crop ( $C_{t-1}$ ), there is tendency to increase the area under pigeon pea in Karnataka.

### **5.3.3.3 Causes of variability in productivity of major pulses in selected states of India**

#### **5.3.3.3.1 Causes of instability in productivity of selected pulse crops in Rajasthan**

The analysis of the data collected during the research it was found from the findings that during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of all selected crops in Rajasthan. Further, seasonal rainfall recorded positive impact on black gram, green gram and pigeon pea crops while on lentil and gram it was negative in Rajasthan.

#### **5.3.3.3.2 Causes of instability in productivity of selected pulse crops in Madhya Pradesh**

The data collected of area, production and productivity of lentil revealed that during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of all selected crops except pigeon pea crop in Madhya Pradesh. Further, seasonal rainfall recorded positive impact on gram, green gram and pigeon pea crops while on lentil and black gram it was negative in Madhya Pradesh.

#### **5.3.3.3.3 Causes of instability in productivity of selected pulse crops in Uttar Pradesh**

From the data it was seen that during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of all selected crops except pigeon pea crop in Uttar Pradesh. Further, seasonal rainfall recorded positive impact on black gram, green gram and pigeon pea crops while on gram and lentil it was negative in Uttar Pradesh.

#### **5.3.3.3.4 Causes of instability in productivity of selected pulse crops in Maharashtra**

The data on analysis revealed that during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of all selected crops in Maharashtra. Further, seasonal rainfall recorded positive impact on all selected crops except gram crops in Maharashtra.

### **5.3.3.3.5 Causes of instability in productivity of selected pulse crops in Karnataka**

On analyzing the data during entire study period (1988-89 to 2017-18), the time trend factor showed positive influence on productivity of gram and pigeon pea crops while negative influence on productivity of black gram and green gram crops in Karnataka. Further, seasonal rainfall recorded positive impact on gram crop while negative influence on productivity of black gram, green gram and pigeon pea crops in Karnataka.

### **5.3.4 Seasonal Behavior in Prices**

#### **5.3.4.1 Seasonal index of Gram in Rajasthan**

From the data it was seen that the highest arrivals index of gram, lentil, black gram, green gram and pigeon pea were found in the month of June (112.61), May (112.62), November (109.14), January (112.13), and February (115.09), respectively and the lowest arrivals index were found in the month of January (87.27), November (83.96), July (89.85), June (85.64) and July (81.64), respectively. The highest price index of gram, lentil, black gram, green gram and pigeon pea were found in the month of January (113.37), November (129.30), July (119.42), June (117.05) and July (115.87) respectively and the lowest price index were found in the month of June (84.90), May (72.22), November (78.98), January (88.56) and February (81.89) respectively. There was inverse relationship between price and arrivals index of gram in the KUMS, Bikaner, lentil in the KUMS, Bundi, black gram in the KUMS, Bundi, green gram in KUMS, Kekari and pigeon pea in the KUMS, Pratapgarh. Price indices of selected crops were lower in the selected markets during harvest season due to distress sale, lack of storage facilities and overdue burden of the farmers.

#### **5.3.4.2 Seasonal index of Gram in Madhya Pradesh**

From the data it was seen that the highest arrivals indices of gram, lentil, black gram, green gram and pigeon pea were found in the month of March (288.96), April (200.51), November (147.31), November (211.24), January (168.31), respectively and the lowest arrivals indices were found in the month of November (18.91), November (42.36), July (62.75), June (59.83) and July (57.68), respectively. The highest price index of gram, lentil, black gram, green gram and pigeon pea were found in the month of November (136.12), November (126.25), July (117.85), June (113.16) and July

(111.85), respectively and the lowest price index were found in the month of March (76.52), April (80.77), November (80.89), January (84.67) and February (81.89), respectively. There was inverse relationship between price and arrivals index of gram in the KUMS, Dewas, lentil in the KUMS, Gorakhpur, black gram in the KUMS, Ganjbasoda, green gram in KUMS, Manawar and pigeon pea in the KUMS, Chhindwara. Price index was lower in the selected market during harvest season due to distress sale, lack of storage facilities and overdue burden of the farmers.

#### **5.4 Conclusions**

The present study leads to the following conclusions:

1. The growth rates in area, production and productivity of gram represented mixed growth pattern in Rajasthan while increasing growth pattern in Madhya Pradesh, Maharashtra and Karnataka and decreasing growth in Uttar Pradesh.
2. There was a significant increase in the area and production of lentil in Rajasthan and Madhya Pradesh, whereas negative growth rates were observed in area and production of Uttar Pradesh and Maharashtra during overall period.
3. During the overall study period, black gram area, production and productivity showed positive and significant growth in Rajasthan, Madhya Pradesh and Uttar Pradesh while in Maharashtra showed negative and significant growth in area and production and Karnataka represented negative growth in production and productivity.
4. Green gram showed positive growth rates in area, production and productivity of Rajasthan, Madhya Pradesh and Uttar Pradesh whereas it showed negative growth rates in area, production and productivity in Maharashtra and negative growth represented in production and productivity of green gram in Karnataka during overall period.
5. The growth rates in area, production and productivity of pigeon pea represented mixed growth pattern in Rajasthan, Madhya Pradesh, Uttar Pradesh, Maharashtra and Karnataka states in all the study periods.
6. During entire study period production and productivity of gram in Rajasthan and area, production and productivity of gram have shown increasing trend

over the years in the Madhya Pradesh, Uttar Pradesh and Maharashtra while in Karnataka, area and production were increased in multiplication form and productivity decreased over the years.

7. The area and production of lentil showed increasing trend while productivity showed a decreasing trend in Rajasthan. In Madhya Pradesh production and productivity showed augmented trend. In Uttar Pradesh area and production represented negative trend behaviour.
8. In Rajasthan and Madhya Pradesh, area, production and productivity of black gram crop showed increasing trend pattern. In Uttar Pradesh, area and production of black gram showed multiplication trend while productivity has shown positive trend pattern.
9. The area, production and productivity of green gram showed increasing trend behavior in Rajasthan, Madhya Pradesh, and Uttar Pradesh. In Maharashtra area and production showed negative trend pattern. In Karnataka, area and production of green gram showed multiplication trend pattern.
10. In Madhya Pradesh, Uttar Pradesh and Karnataka, area, production and productivity of pigeon pea crop showed positive trend pattern. In Maharashtra, area and production represented affirmative trend pattern.
11. The area and interaction effect were the major factors that accounted for the gram crop output in Rajasthan. In Madhya Pradesh, interaction effect was more dominant to produce the output of gram. In Uttar Pradesh and Karnataka, area effect was the major factor to produce output of gram. The yield and area effect were the major factors leading to the increased output in Maharashtra.
12. The analysis revealed that change in area effect was the major source of output growth of lentil crop in Rajasthan. The production was increased due to area and yield effect in Madhya Pradesh and Uttar Pradesh while area and interaction were the major factors to increase produce of output in Maharashtra.
13. The data revealed that yield and area effect were more dominant in black gram of Rajasthan. Area effect was the major factor to bring about change in production of black gram in Madhya Pradesh, Uttar Pradesh and Karnataka

while yield and interaction effect were the major factors to bring change in production of black gram in Maharashtra.

14. From the data it was seen that in Rajasthan and Karnataka, area and interaction effect was more dominant to increase the output of green gram. In Uttar Pradesh and Maharashtra, yield effect was major contributor to change the production of green gram. Area and yield effect were major source of growth of production of green gram.
15. The analysis revealed that area and interaction effect were the major factors that accounted for the pigeon pea crop output in Rajasthan. In Madhya Pradesh, area and yield effect were more dominant to increase the output of pigeon pea. In Uttar Pradesh, yield effect was the major factor to produce output of pigeon pea. The area effect was the major factor to increase the output in Maharashtra. The yield and interaction effect were the major factors that accounted for increase in the pigeon pea crop output in Karnataka.
16. It was observed that variability in production was higher than area and productivity of gram, lentil, black gram, green gram and pigeon pea in all selected states of India.
17. It was observed that with the decline in area of competing crop ( $C_{t-1}$ ), there was a tendency to increase the area under gram and green gram in all selected states of India.
18. The analysis revealed that with the increase in area of lentil in last year season; there was tendency to increase the area under lentil in all selected states of India.
19. From the data it was seen that with the decline in area of competing crop ( $C_{t-1}$ ), there was tendency to increase the area under black gram in Rajasthan and Maharashtra while augmented area of black gram in last season, there was tendency to increase the area under black gram in Madhya Pradesh, Uttar Pradesh and Karnataka.
20. From the analysis it was seen that with the decline in area of competing crop ( $C_{t-1}$ ), there was tendency to increase the area under pigeon pea in Uttar Pradesh and Karnataka while in augmented area of pigeon pea in last year

season, there was tendency to increase the area under pigeon pea in Rajasthan, Madhya Pradesh and Maharashtra.

21. From the analysis of the data collected during the research it was found that the time trend factor showed positive influence on productivity of gram in all selected states of India. Further, seasonal rainfall recorded positive impact on gram in Madhya Pradesh and Karnataka while negative impact on gram was recorded in Rajasthan, Uttar Pradesh and Maharashtra.
22. The data revealed that, the time trend factor showed positive influence on productivity of lentil in all selected states of India. Further, seasonal rainfall recorded negative impact on lentil in all the states except in Maharashtra.
23. From the analysis of the data collected during the research it was found that the time trend factor showed positive influence on productivity of black gram in all the selected states of India except Karnataka. Further, seasonal rainfall recorded positive impact on black gram in Rajasthan, Uttar Pradesh and Maharashtra while negative impact on black gram was recorded in Madhya Pradesh and Karnataka.
24. The analysis of data revealed that the time trend factor showed positive influence on productivity of green gram in all selected states of India except Karnataka. Further, seasonal rainfall recorded positive impact on green gram in all selected states of India except Karnataka.
25. From the analysis of the data collected during the research it was found from the findings that, the time trend factor showed positive influence on productivity of pigeon pea in all selected states of India i.e. Madhya Pradesh and Uttar Pradesh. Further, seasonal rainfall recorded positive impact on pigeon pea in all selected states of India except Karnataka.
26. From the data it was seen that there was inverse relationship between price and arrivals of gram, lentil, black gram, green gram and lentil in all selected KUMS of Rajasthan and Madhya Pradesh.

## **5.5 Policy implications**

Following policy recommendations emerged from the study:

1. Negative growth in area, production and productivity of gram in Rajasthan, pigeon pea in Uttar Pradesh, black gram and green gram in Maharashtra and black gram in Karnataka during 1997-98 to 2007-08 (period-II) and lentil in Uttar Pradesh during all the study periods (period-I, II, III and overall) were noticed because of shift in area from these crops to other competitive crops. Thus, there is a need to give more emphasis on both technological aspects as well as policy aspects (extension services and more remunerative prices) so that with increase in area and productivity of these pulse crops, production can be increased.
2. Decreasing trend was found in productivity of gram in Rajasthan. Hence, farmers may be advised to follow all the improved package of practices to improve the production of gram in the state and to gear up the extension agency to transfer these technologies on farmers fields.
3. It was observed that area effect was more dominant compared to yield and interaction effect of lentil in Rajasthan, black gram in Madhya Pradesh and gram in Karnataka in all the study period (period-I, II, III and overall). Therefore, for above crops of respective states, technological improvement aspect can play a big role to increase production of these pulse crops.
4. Seasonal Indices of prices for all selected pulse crops in Rajasthan and Madhya Pradesh states were the lowest at the time of harvest. Therefore strategies may be framed to increase the storage capacity in the producing area and provide marketing loan to the farmers on the basis of stored commodity in the ware houses/ cooperatives to reduce post harvest sales of pulses.



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# **Dynamics of Area and Production of Major Pulse Crops in India**

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## **ABSTRACT**

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The present study entitled “Dynamics of Area and Production of Major Pulse Crops in India” was conducted to examine the growth and trend, decomposition, instability and causes of instability and seasonal index of major pulse crops in major states of India. The study was based on secondary data collected from different sources i.e. Directorate of Agriculture and Cooperation, GOI, Directorate of Pulses development Bhopal, etc. The time series data of area, production and productivity of major pulse crops in selected states of India have been taken for 30 years from 1988-89 to 2017-18 for the analysis of growth, trend, decomposition and instability whereas growth and decomposition were calculated period wise as period-I (1988-89 to 1997-98), period-II (1998-99 to 2007-08), period-III (2008-89 to 2017-18) and overall period (1988-89 to 2017-18). The fourth objective was based on seasonal variation of selected pulse crops in Rajasthan and Madhya Pradesh. Ten years (January, 2008 to December 2017) monthly time series data on arrivals and wholesale prices were collected to estimate the seasonal variation of selected pulse crops in Rajasthan and Madhya Pradesh. Compound growth rate in area, production and productivity, log linear form of equations (also known as exponential function) were used to estimate. Linear, quadratic and exponential functions were used to estimate trend pattern in area production and productivity of selected pulse crops in selected states. The function which had the highest coefficient of determination among above three functions was used to estimate trend. The coefficient of variation for instability analysis was computed by Cuddy Della Valle Index. Acreage response function was used to estimate for determining the causes of instability. Similarly, yield response was used to estimate the causes of variability in yield in major pulse crops of selected states of India. It was revealed from the results that during overall study period, the highest and significant growth was found in area, production and productivity of green gram in

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Uttar Pradesh at the rate of 13.76, 22.18 and 7.40 per cent, respectively and the lowest and significant growth was observed in area, production and productivity of pigeon pea in Uttar Pradesh at the rate of -5.16, -7.96 and -2.96 per cent, respectively amongst all selected pulse crops. During the entire study period, the highest and significant trend was found in area and production of black gram in Uttar Pradesh and productivity of black gram in Madhya Pradesh at the rate of 0.043 and 0.060 and 0.779 respectively. The lowest and significant trend was found in area and production of black gram in Maharashtra at the rate of -0.010 and lowest trend in productivity shown in gram in Karnataka at the rate of -0.383. Considering all the 5 states, in Maharashtra, area effect of lentil crop was the highest with the magnitude of 172.21 per cent whereas yield effect was found to be the highest 75.16 per cent in Maharashtra and the interaction effect was found to be maximum in Karnataka at the rate of 627.38 per cent during the entire study period. The area effect was found to be the lowest in black gram in Maharashtra at the rate of -562.84 per cent whereas yield and interaction effect was observed at the rate of -295.46 and -126.28 per cent respectively in Karnataka and Maharashtra during overall study period. The instability in area was the highest in pigeon pea (52.29%) of Rajasthan and the lowest in pigeon pea (7.09%) of Uttar Pradesh. The production was higher instable in green gram (59.25%) in Madhya Pradesh and the lowest in pigeon pea (12.82%). The productivity was the highest in black gram (44.84%) of Karnataka and the lowest in lentil in Uttar Pradesh at the rate of 10.57 per cent during entire study period. From the data it was seen that with the decline in area of competing crop ( $C_{t-1}$ ), there was a tendency to increase the area under gram and green gram in all selected states of India. It was found from the findings that the time trend factor showed positive influence on productivity of gram in all selected states of India. From the data it was seen that there was inverse relationship between price and arrivals of gram, lentil, black gram, green gram and lentil in all the selected Krishi Upaj Mandi Samiti of Rajasthan and Madhya Pradesh.

# भारत में प्रमुख दलहन फसलों के क्षेत्र और उत्पादन की गतिशीलता

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प्रमुख सलाहकार

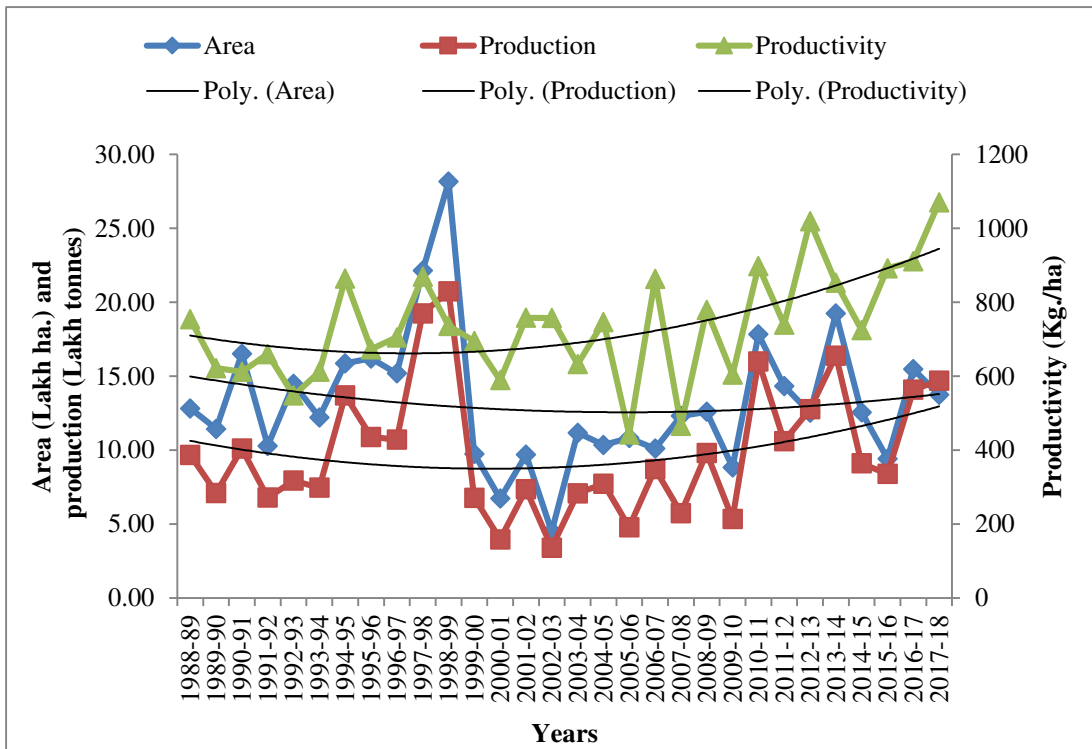
## अनुक्षेपण

भारत के प्रमुख राज्यों में प्रमुख दलहनी फसलों की वृद्धि और प्रवृत्ति, अपघटन, अस्थिरता और अस्थिरता के कारणों और मौसमी सूचकांक की जांच के लिए "भारत में प्रमुख दलहन फसलों के क्षेत्र और उत्पादन की गतिशीलता" नामक वर्तमान अध्ययन किया गया था। अध्ययन विभिन्न स्रोतों अर्थात् कृषि एवं सहकारिता निदेशालय, भारत सरकार, दलहन विकास निदेशालय भोपाल, आदि से एकत्रित द्वितीयक आंकड़ों पर आधारित था। भारत के चुनिंदा राज्यों में प्रमुख दलहनी फसलों के क्षेत्रफल, उत्पादन और उत्पादकता का समय श्रृंखला डेटा विकास, प्रवृत्ति, अपघटन और अस्थिरता के विश्लेषण के लिए 1988-89 से 2017-18 तक 30 वर्षों के लिए लिया गया है, जिससे वृद्धि और अपघटन की गणना की गई थी जैसे अवधि-I (1988-89 से 1997-98), अवधि-II (1998-99 से 2007-08), अवधि-III (2008-09 से 2017-18) और समग्र अवधि। चौथा उद्देश्य राजस्थान और मध्य प्रदेश में चयनित दलहनी फसलों के मौसमी बदलाव पर आधारित था। राजस्थान और मध्य प्रदेश में चयनित दलहनी फसलों की मौसमी भिन्नता का अनुमान लगाने के लिए आवक और थोक मूल्यों पर दस साल (जनवरी, 2008 से दिसंबर 2017) मासिक समय श्रृंखला डेटा एकत्र किया गया था। क्षेत्र, उत्पादन और उत्पादकता में चक्रवृद्धि वृद्धि दर, समीकरणों के लॉग रैखिक रूप (जिसे घातांक फंक्शन के रूप में भी जाना जाता है) का अनुमान लगाने के लिए उपयोग किया गया था। चयनित राज्यों में चयनित दलहनी फसलों के क्षेत्र उत्पादन और उत्पादकता में प्रवृत्ति पैटर्न का अनुमान लगाने के लिए रैखिक, द्विघात और घातीय फंक्शन का उपयोग किया गया था। उपरोक्त तीन फंक्शन के बीच निर्धारण के उच्चतम गुणांक वाले फंक्शन का उपयोग प्रवृत्ति का अनुमान लगाने के लिए किया गया था। अस्थिरता विश्लेषण के लिए भिन्नता के गुणांक की गणना कडुई डेला वैले इंडेक्स द्वारा की गई थी। अस्थिरता के कारणों का निर्धारण करने के लिए अनुमान रकबा प्रतिक्रिया फंक्शन का उपयोग किया गया था। इसी प्रकार, भारत के चयनित राज्यों की प्रमुख दलहन फसलों में उपज के कारणों का अनुमान लगाने के लिए उपज प्रतिक्रिया का उपयोग किया गया था। परिणामों से पता चला कि समग्र अध्ययन अवधि के दौरान उत्तर प्रदेश में हरे चने के क्षेत्रफल, उत्पादन और उत्पादकता में क्रमशः 13.76, 22.18 और 7.40 प्रतिशत की दर से उच्चतम और महत्वपूर्ण वृद्धि पाई गई और सबसे कम और महत्वपूर्ण वृद्धि हुई। उत्तर प्रदेश में अरहर के क्षेत्रफल, उत्पादन और उत्पादकता में सभी चयनित दलहनी फसलों में क्रमशः -5.16, -7.96 और -2.96 प्रतिशत की दर से देखा गया। सम्पूर्ण अध्ययन

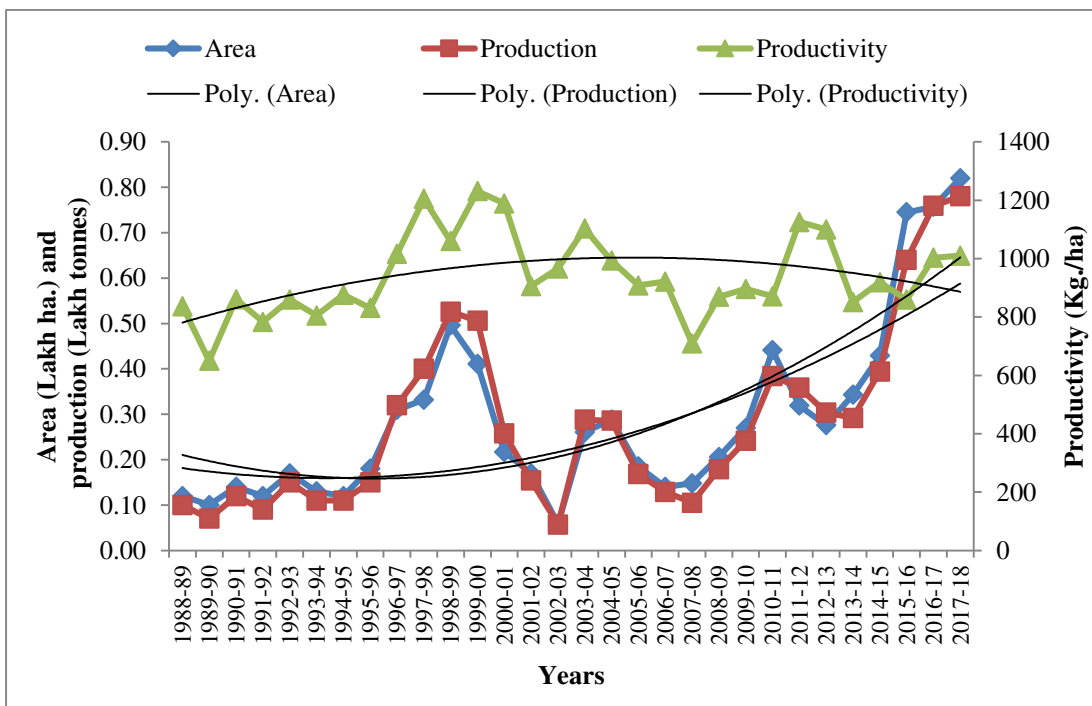
\* शोधकर्ता -विद्यावाचस्पति कृषि अर्थशास्त्र एवं प्रबन्धन विभाग, आरसीए, उदयपुर।

\*\* सहायक आचार्य एवं प्रभारी, कृषि अर्थशास्त्र एवं प्रबन्धन विभाग, आरसीए, उदयपुर।

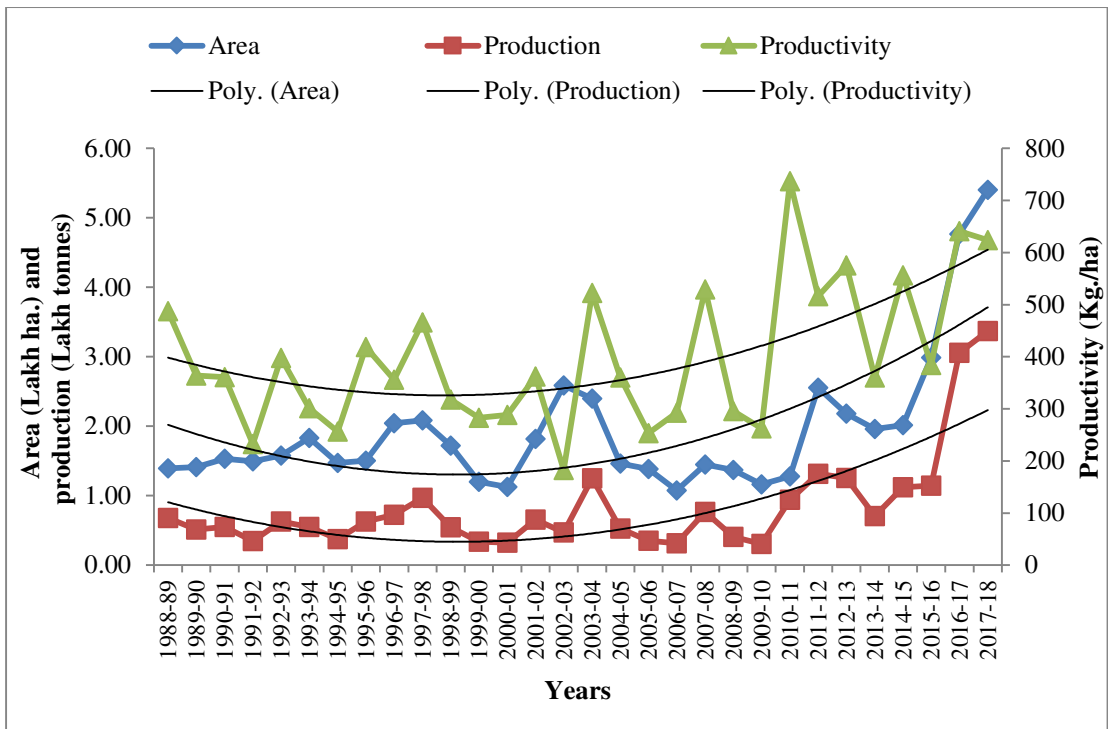
अवधि के दौरान उत्तर प्रदेश में काले चने के रकबे एवं उत्पादन तथा मध्य प्रदेश में काले चने की उत्पादकता क्रमशः 0.043 एवं 0.060 एवं 0.779 की दर से सर्वाधिक एवं महत्वपूर्ण प्रवृत्ति पायी गयी। महाराष्ट्र में काले चने के क्षेत्रफल और उत्पादन में -0.010 की दर से सबसे कम और महत्वपूर्ण प्रवृत्ति और कर्नाटक में -0.383 की दर से चना की उत्पादकता में सबसे कम प्रवृत्ति पाई गई। सभी 5 राज्यों को ध्यान में रखते हुए, महाराष्ट्र में, मसूर की फसल का क्षेत्रफल 172.21 प्रतिशत की परिमाण के साथ सबसे अधिक था, जबकि उपज प्रभाव महाराष्ट्र में सबसे अधिक 75.16 प्रतिशत पाया गया था और कर्नाटक में पारस्परिक प्रभाव सबसे अधिक पाया गया था। जो संपूर्ण अध्ययन अवधि के दौरान 627.38 प्रतिशत की दर थी। समग्र अध्ययन अवधि के दौरान महाराष्ट्र में काले चने में क्षेत्र प्रभाव -562.84 प्रतिशत की दर से सबसे कम पाया गया, जबकि कर्नाटक और महाराष्ट्र में उपज और अंतःक्रियात्मक प्रभाव क्रमशः -295.46 और -126.28 प्रतिशत की दर से देखा गया। क्षेत्र में अस्थिरता राजस्थान के अरहर (52.29 प्रतिशत) में सबसे अधिक और उत्तर प्रदेश के अरहर (7.09 प्रतिशत) में सबसे कम थी। मध्य प्रदेश में हरे चने (59.25 प्रतिशत) में उत्पादन अधिक और अरहर (12.82 प्रतिशत) प्रतिशत में सबसे कम था। संपूर्ण अध्ययन अवधि के दौरान कर्नाटक के काले चने (44.84 प्रतिशत) में उत्पादकता सबसे अधिक और उत्तर प्रदेश में सबसे कम 10.57 प्रतिशत की दर से मसूर की थी। आंकड़ों से यह देखा गया कि प्रतिस्पर्धी फसल (सी<sub>क-1</sub>) के क्षेत्र में गिरावट के साथ, भारत के सभी चयनित राज्यों में चना और हरे चने के तहत क्षेत्र में वृद्धि करने की प्रवृत्ति थी। निष्कर्षों से यह पाया गया कि भारत के सभी चयनित राज्यों में समय प्रवृत्ति कारक ने चने की उत्पादकता पर सकारात्मक प्रभाव दिखाया। आंकड़ों से यह देखा गया कि राजस्थान और मध्य प्रदेश के सभी चयनित कृषि उपज मंडी समिति में चना, मसूर, काला चना, हरा चना और मसूर की कीमत और आवक के बीच विपरीत संबंध था।



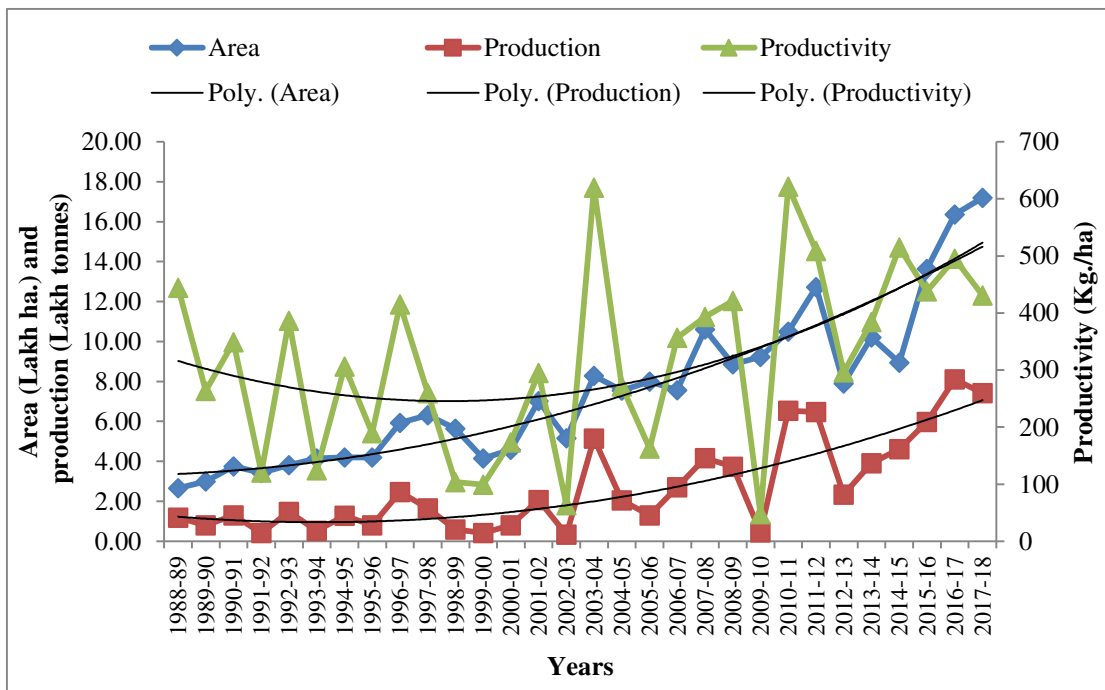
**Figure 4.1: Trend in area, production and productivity of gram in Rajasthan**



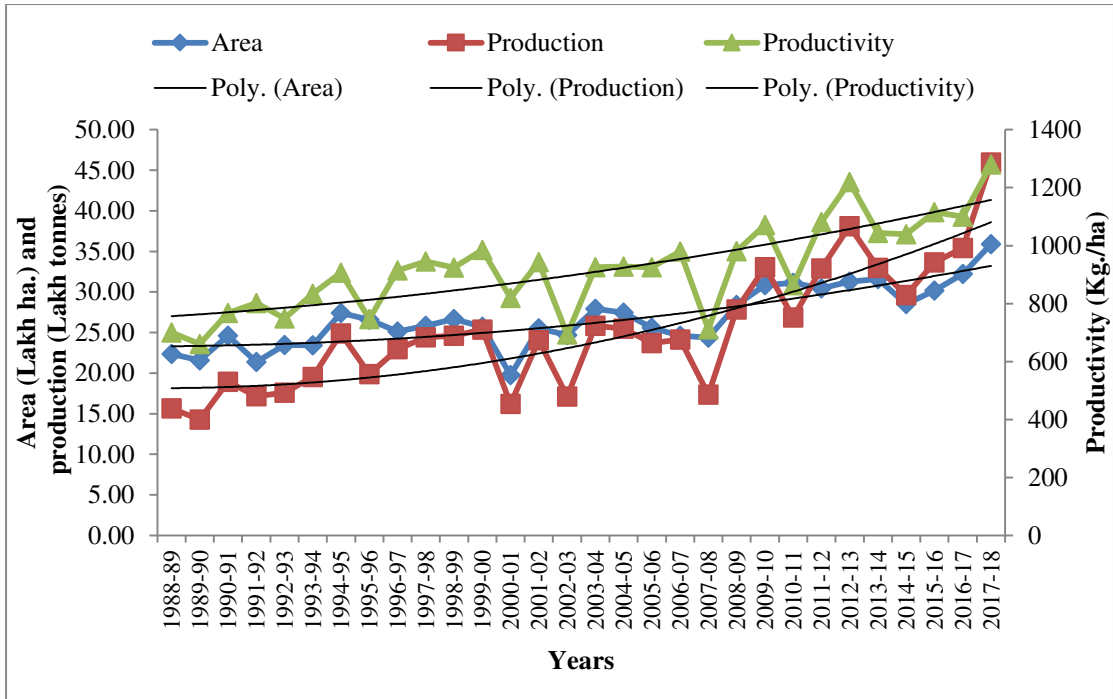
**Figure 4.2: Trend in area, production and productivity of lentil in Rajasthan**



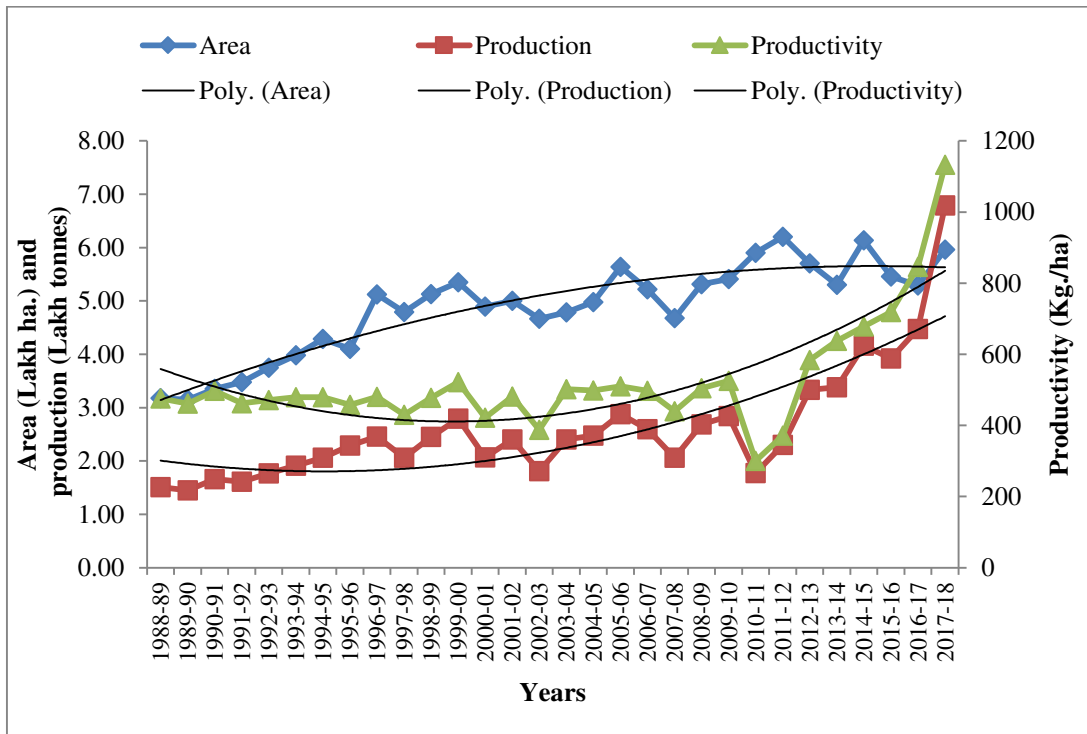
**Figure 4.3: Trend in area, production and productivity of black gram in Rajasthan**



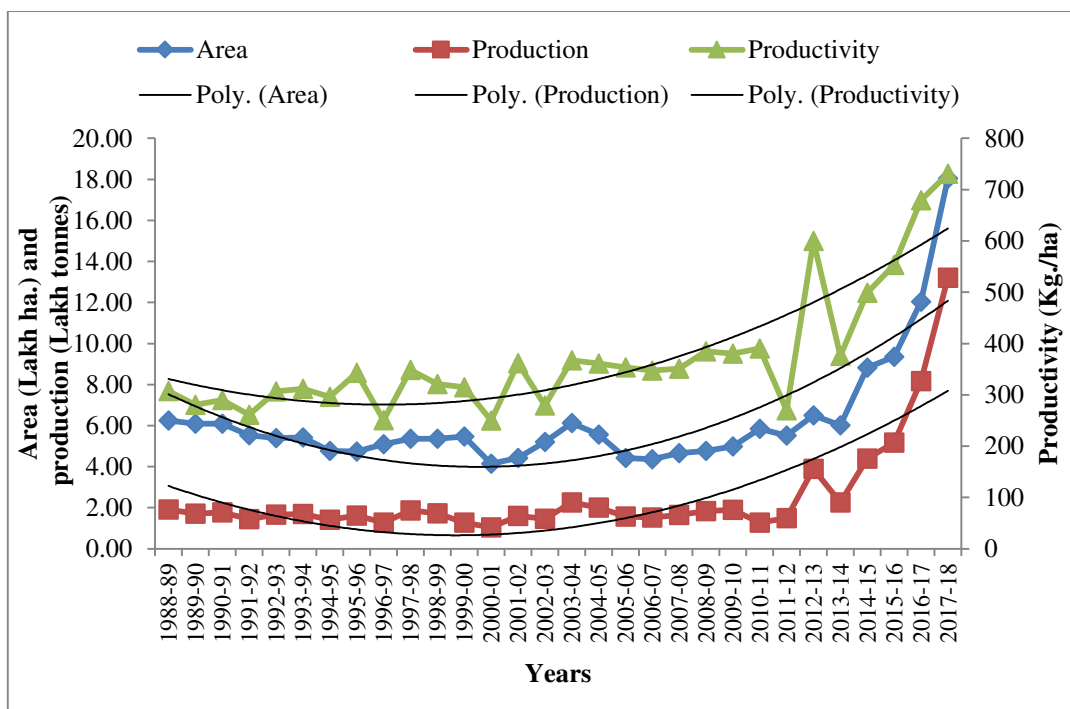
**Figure 4.4: Trend in area, production and productivity of green gram in Rajasthan**



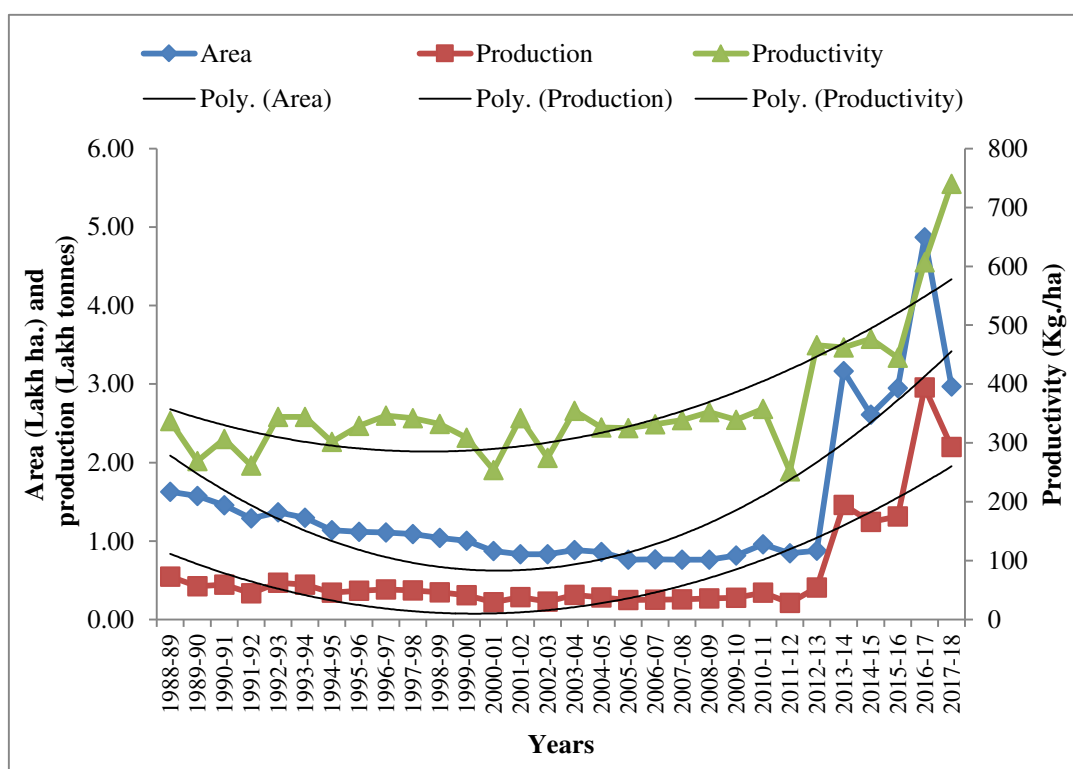
**Figure 4.5: Trend in area, production and productivity of gram in Madhya Pradesh**



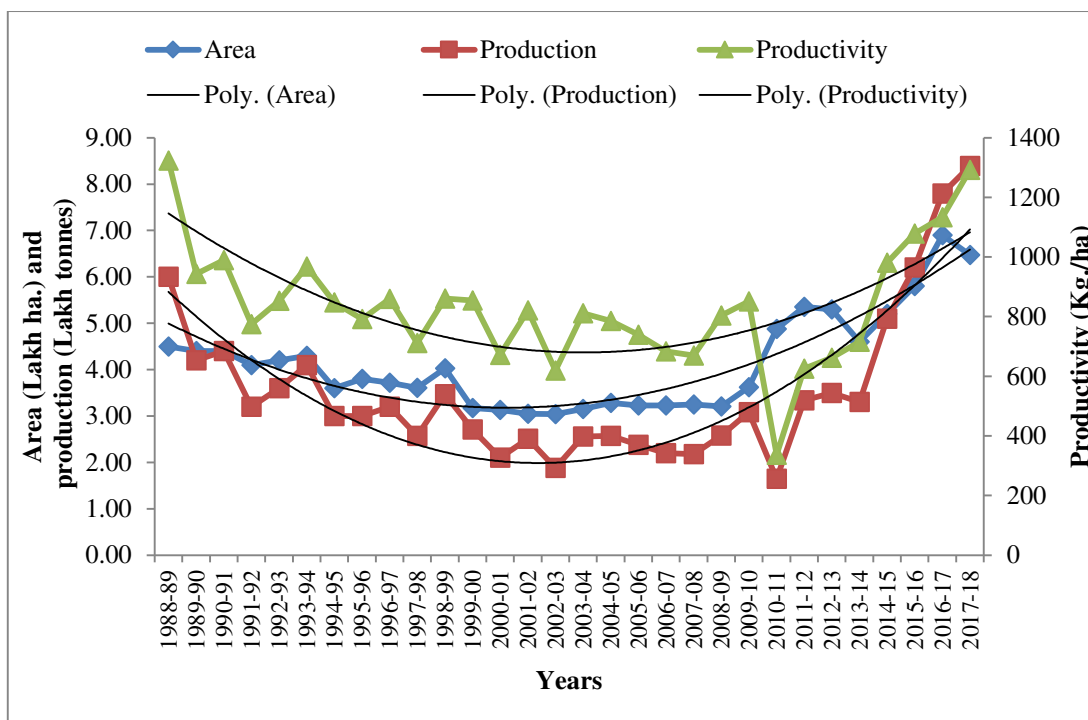
**Figure 4.6: Trend in area, production and productivity of lentil in Madhya Pradesh**



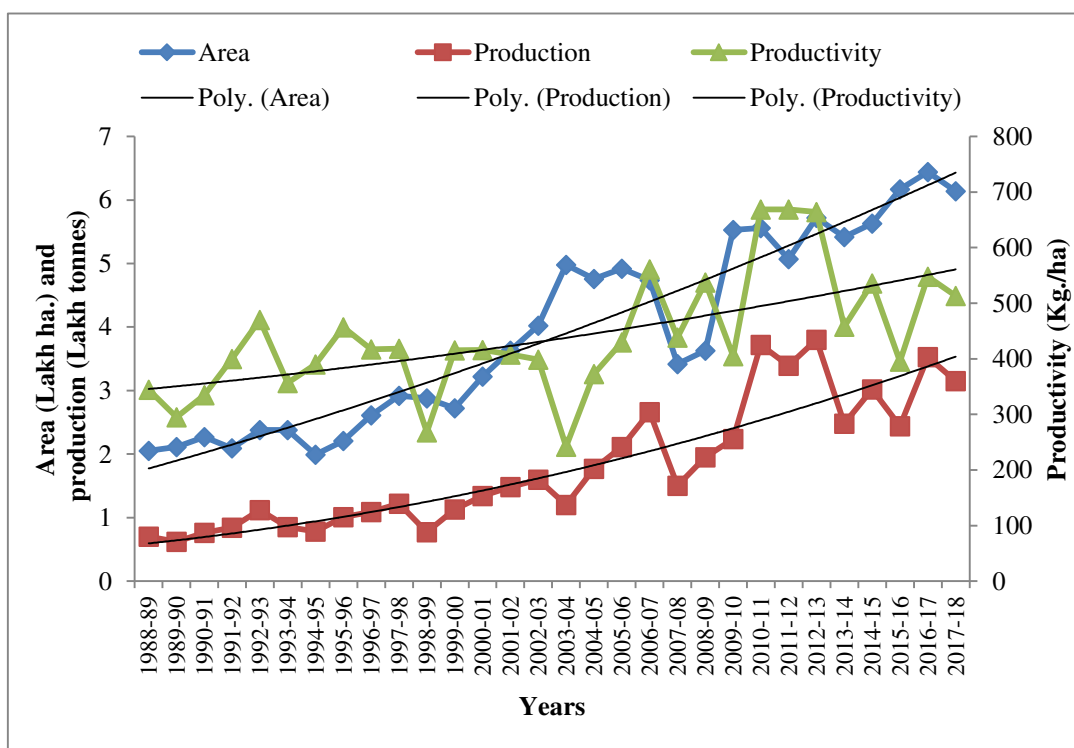
**Figure 4.7: Trend in area, production and productivity of black gram in Madhya Pradesh**



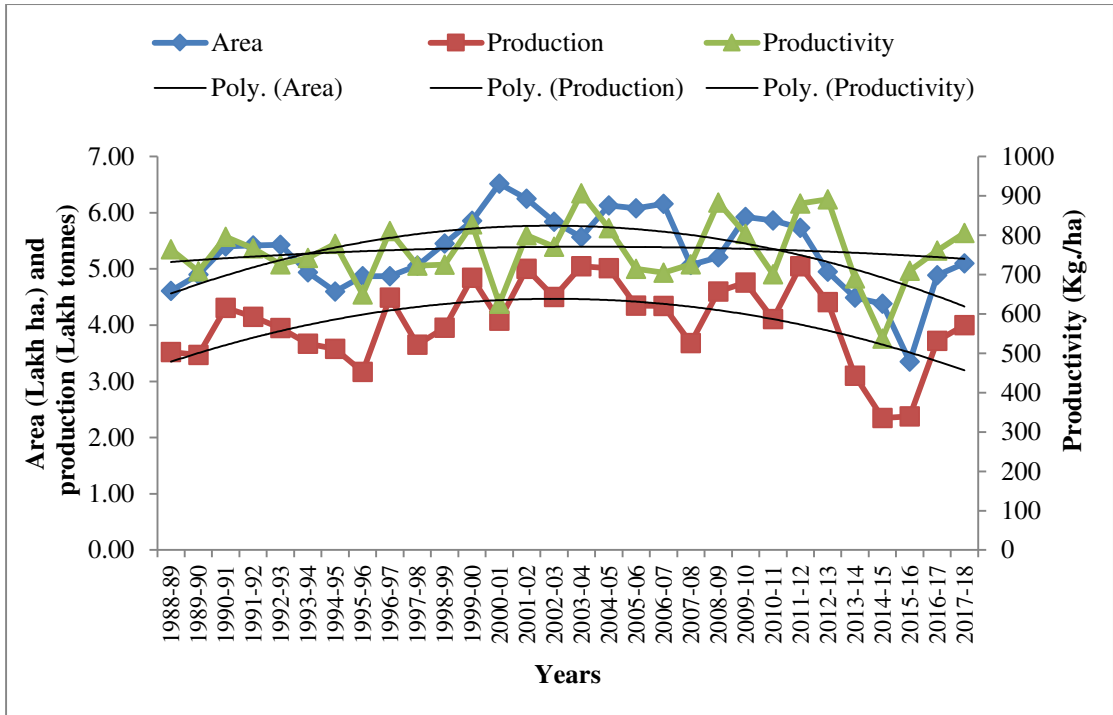
**Figure 4.8: Trend in area, production and productivity of green gram in Madhya Pradesh**



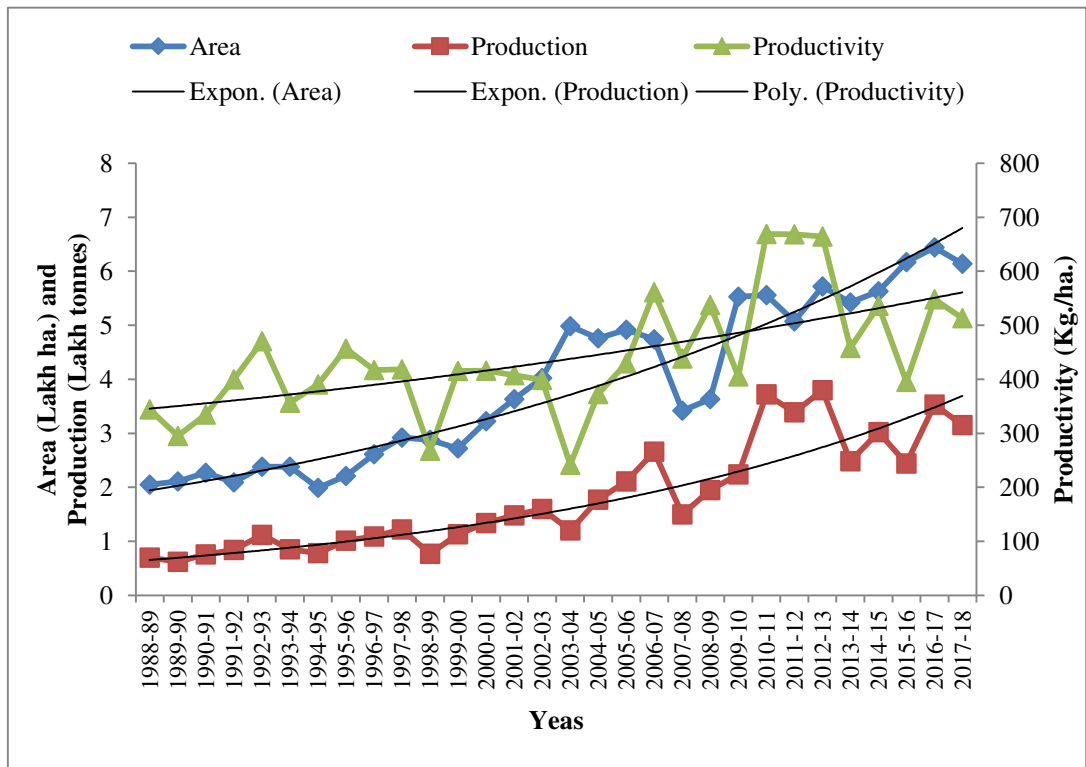
**Figure 4.9: Trend in area, production and productivity of pigeon pea in Madhya Pradesh**



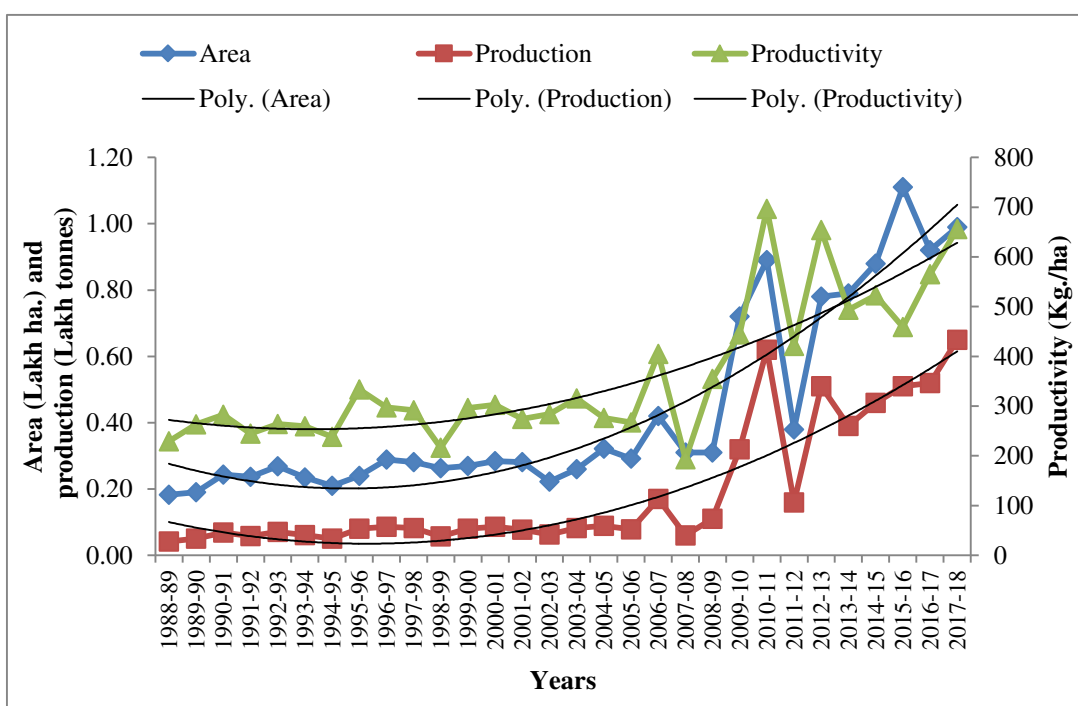
**Figure 4.10: Trend in area, production and productivity of gram in Uttar Pradesh**



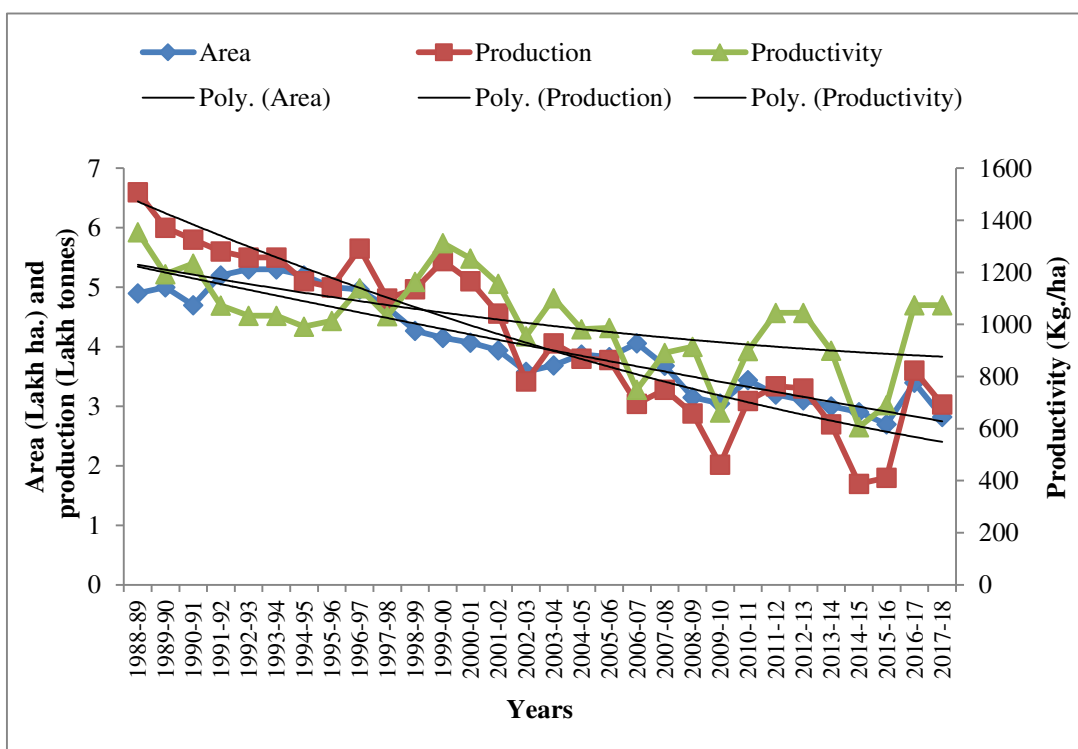
**Figure 4.11: Trend in area, production and productivity of lentil in Uttar Pradesh**



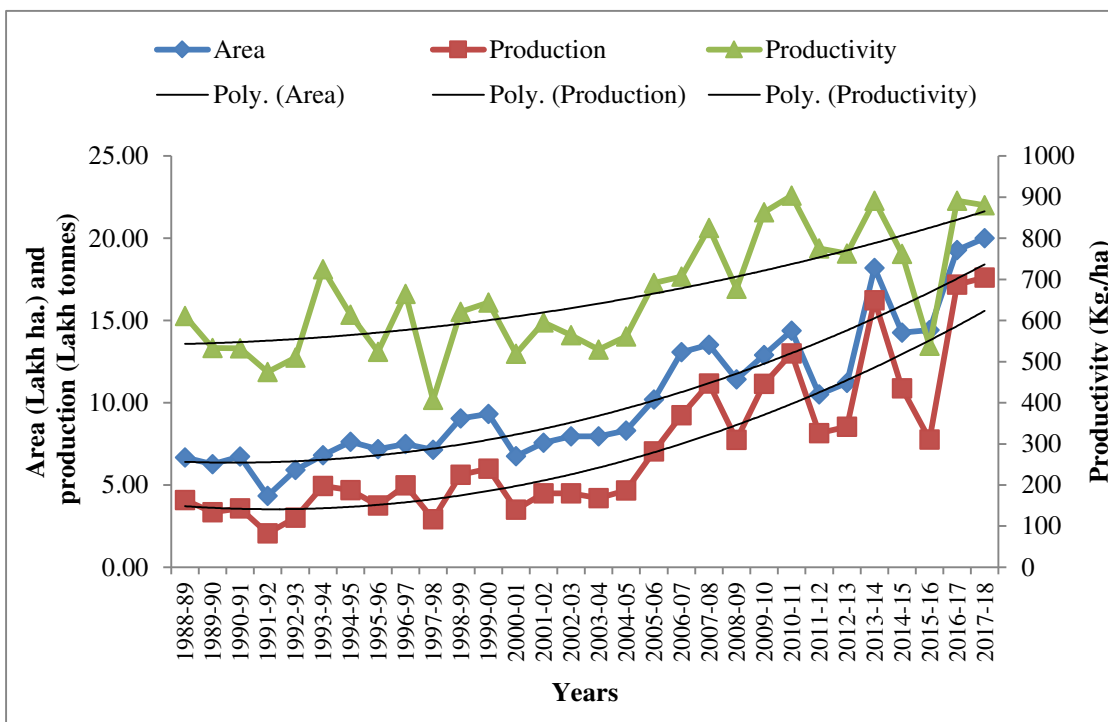
**Figure 4.12: Trend in area, production and productivity of black gram in Uttar Pradesh**



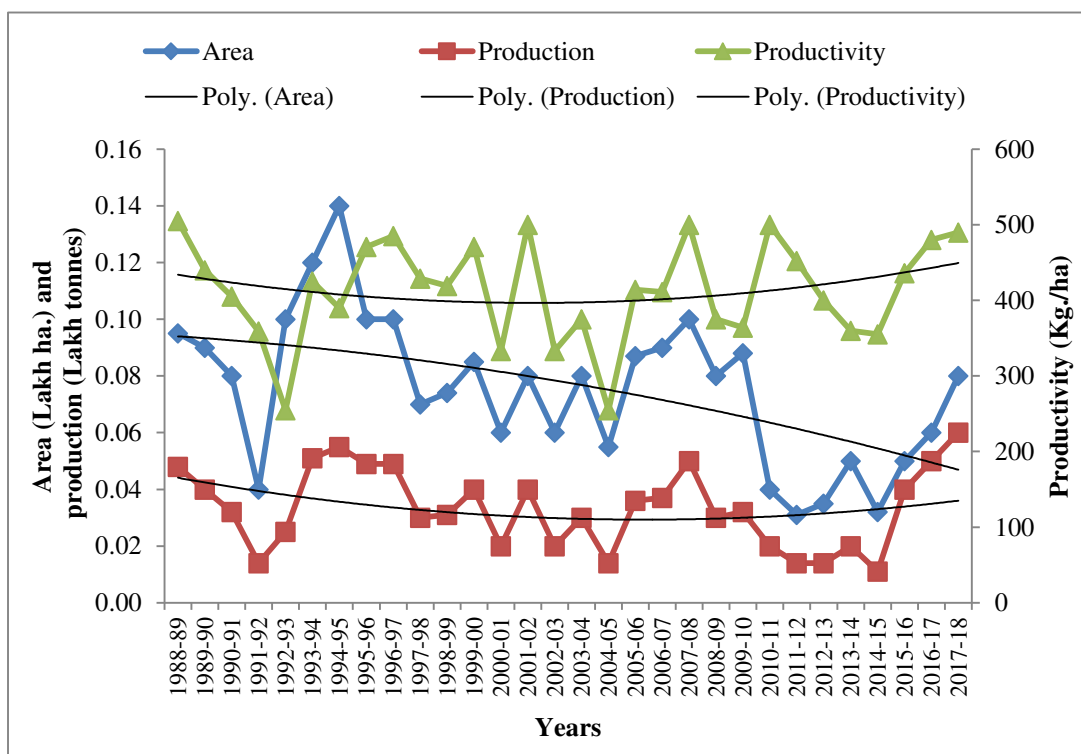
**Figure 4.13: Trend in area, production and productivity of green gram in Uttar Pradesh**



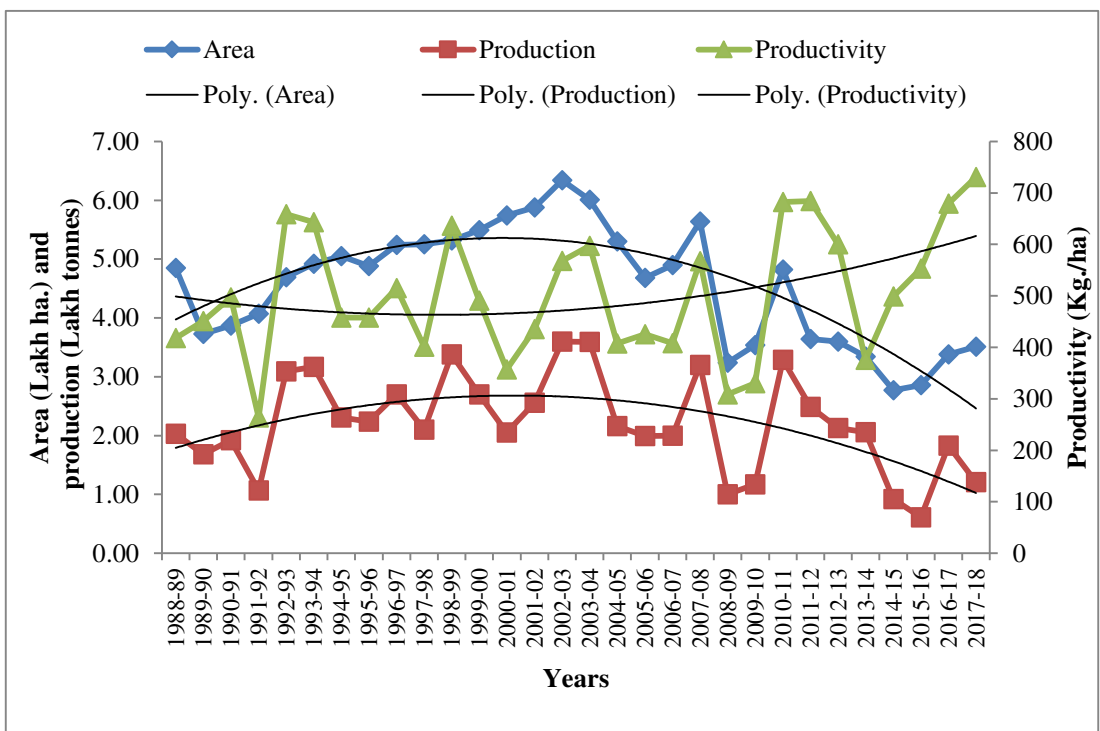
**Figure 4.14: Trend in area, production and productivity of pigeon pea in Uttar Pradesh**



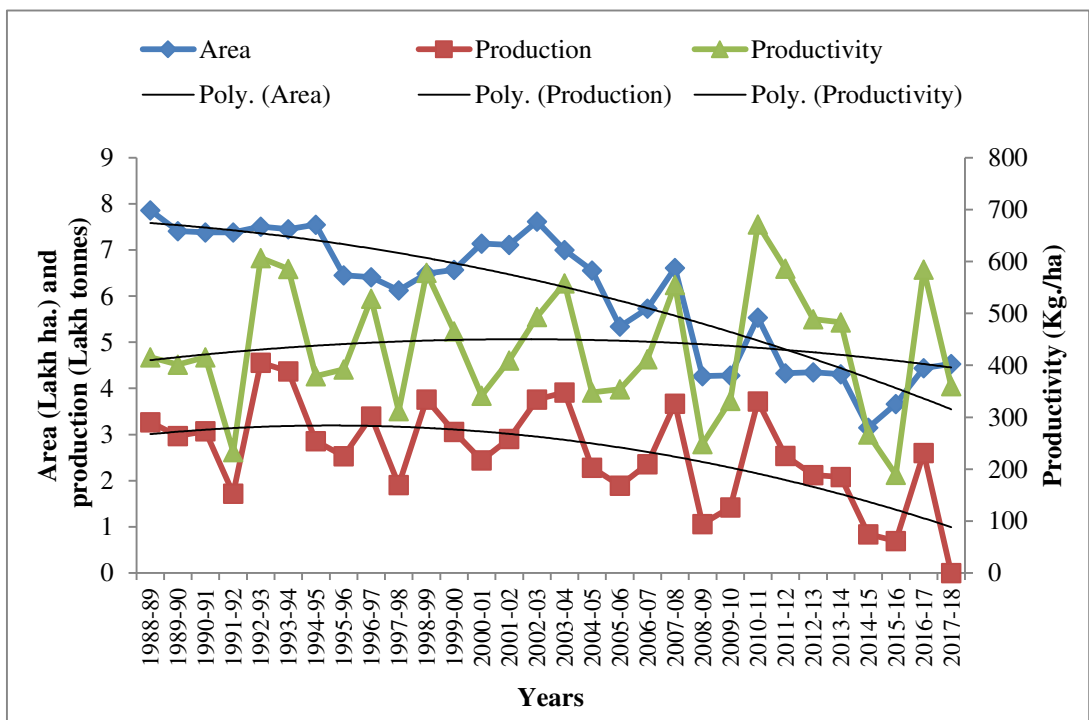
**Figure 4.15: Trend in area, production and productivity of gram in Maharashtra**



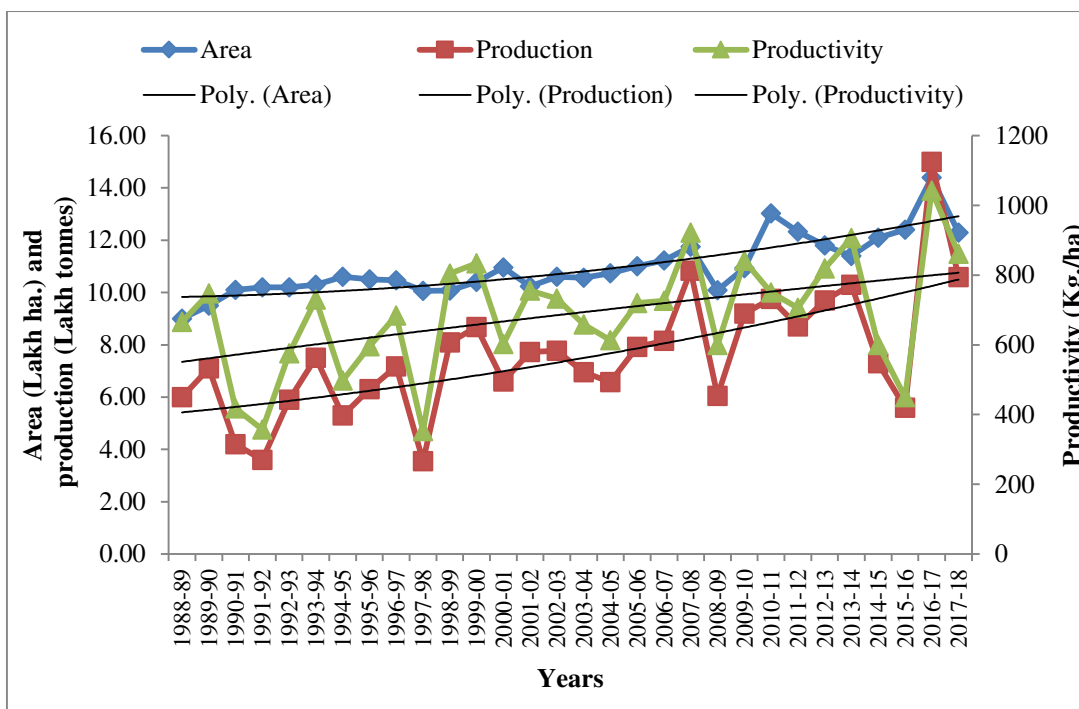
**Figure 4.16: Trend in area, production and productivity of lentil in Maharashtra**



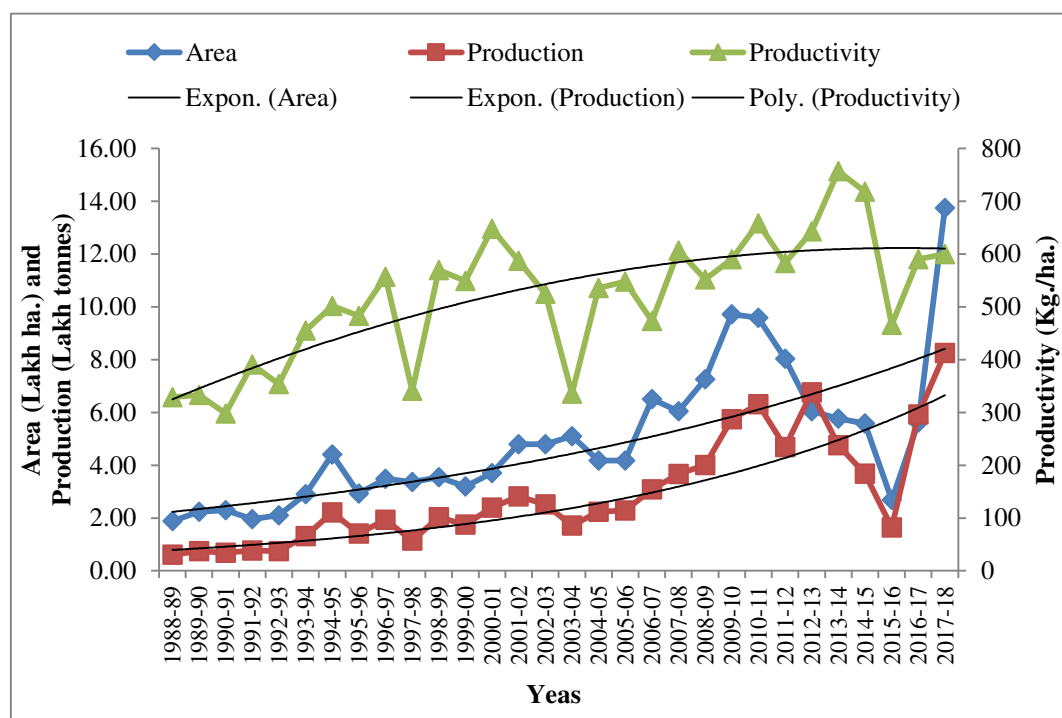
**Figure 4.17: Trend in area, production and productivity of black gram in Maharashtra**



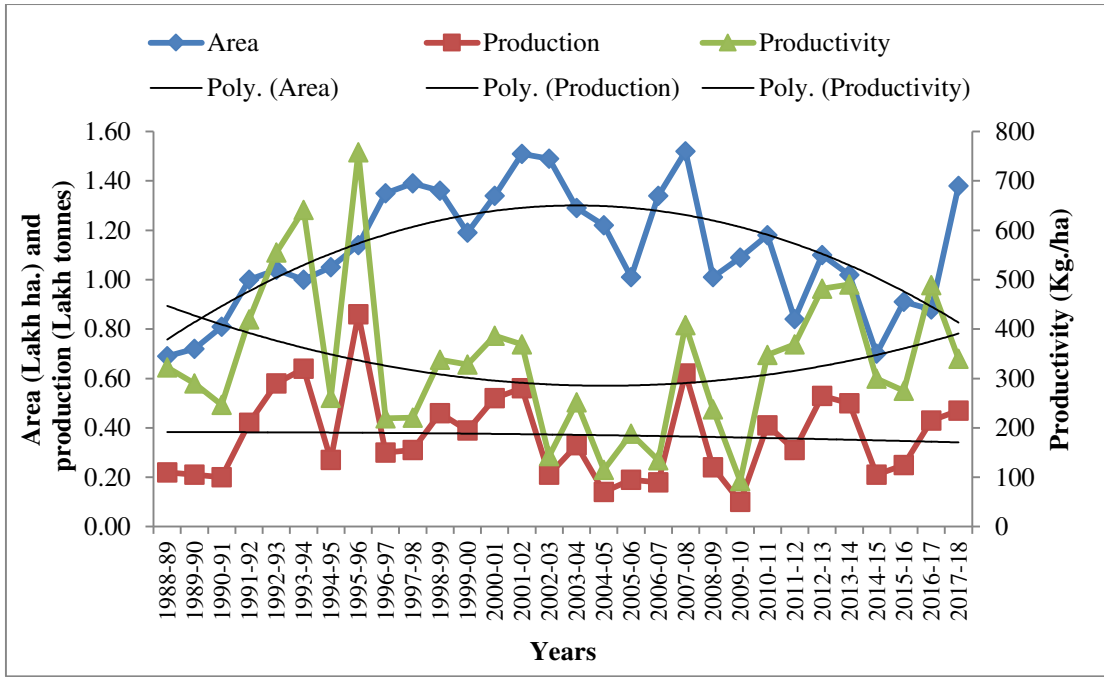
**Figure 4.18: Trend in area, production and productivity of green gram in Maharashtra**



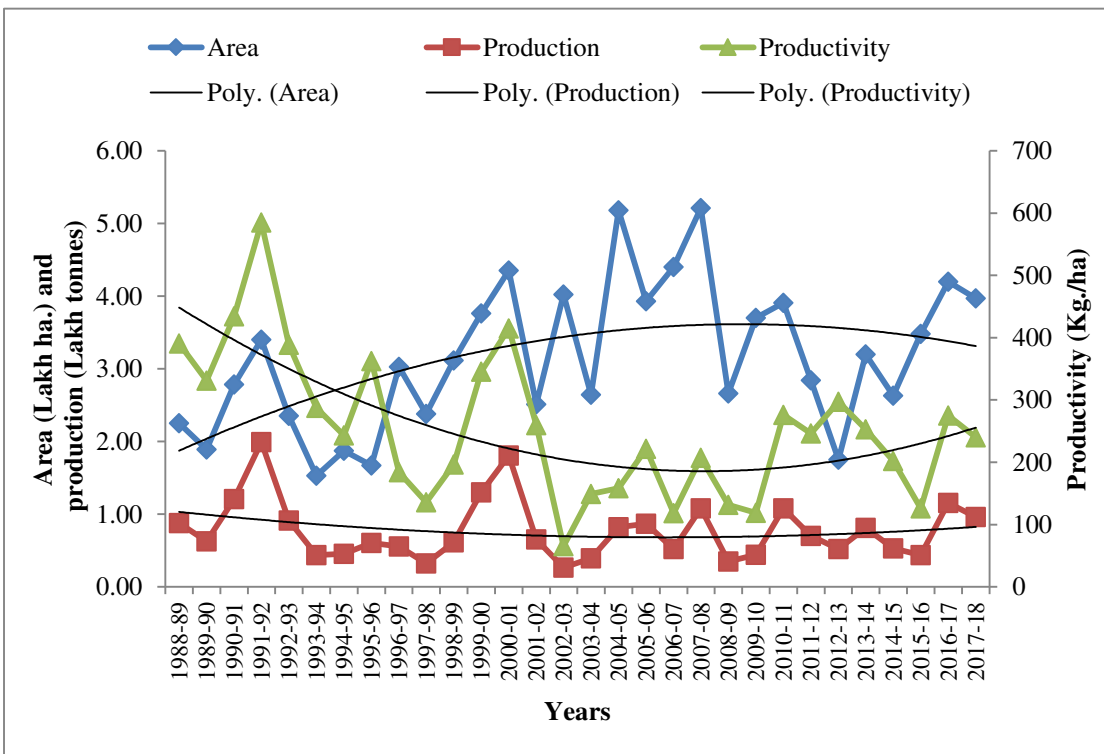
**Figure 4.19: Trend in area, production and productivity of pigeon pea in Maharashtra**



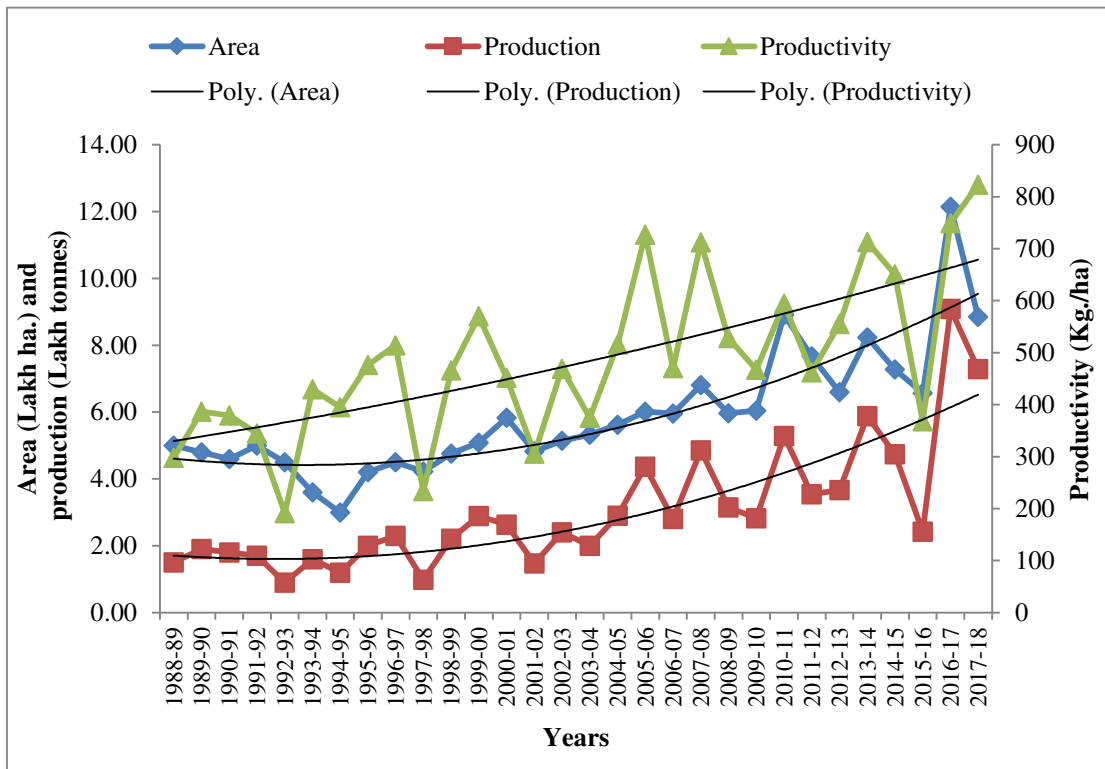
**Figure 4.20: Trend in area, production and productivity of gram in Karnataka**



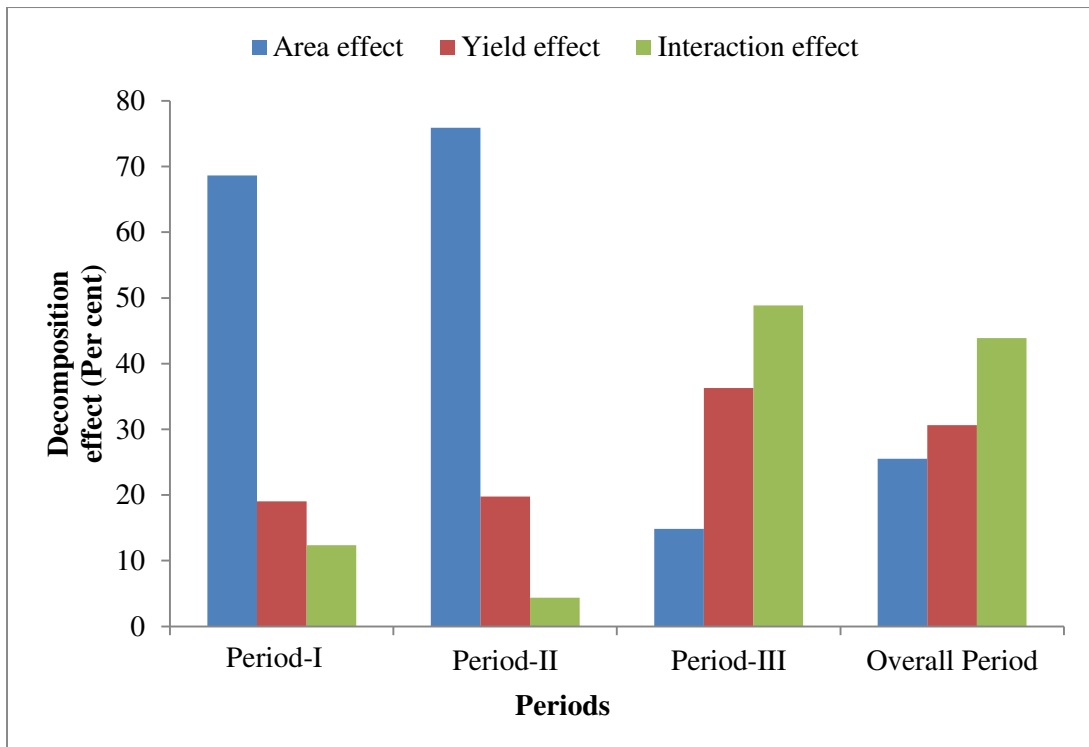
**Figure 4.21: Trend in area, production and productivity of black gram in Karnataka**



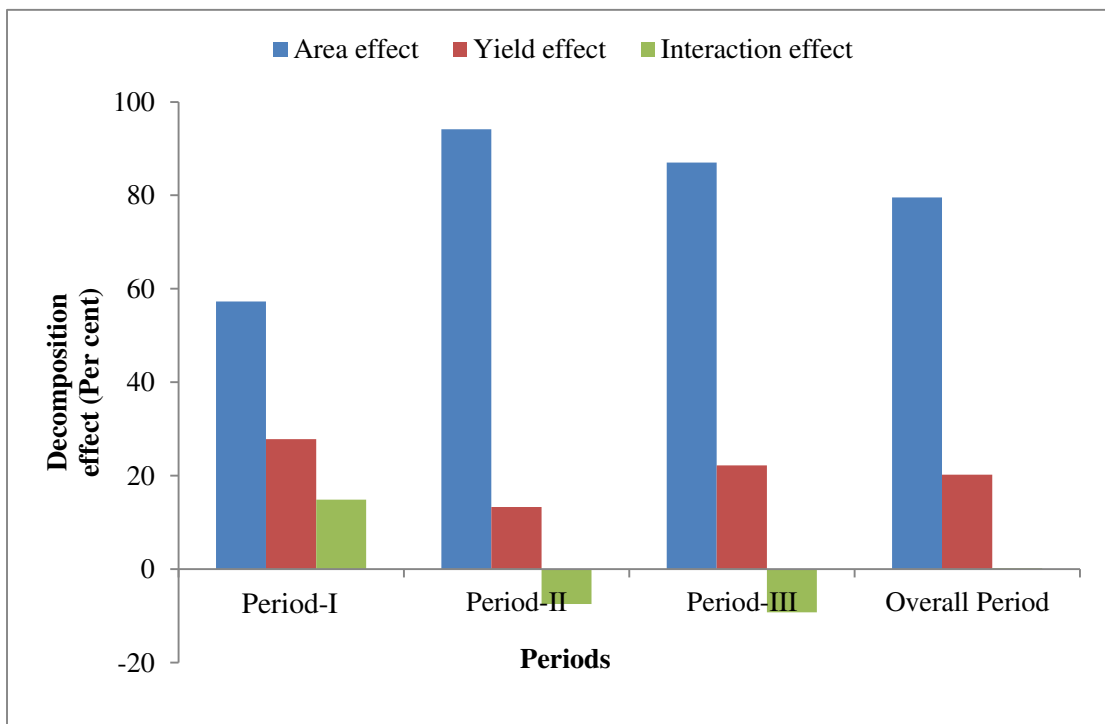
**Figure 4.22: Trend in area, production and productivity of green gram in Karnataka**



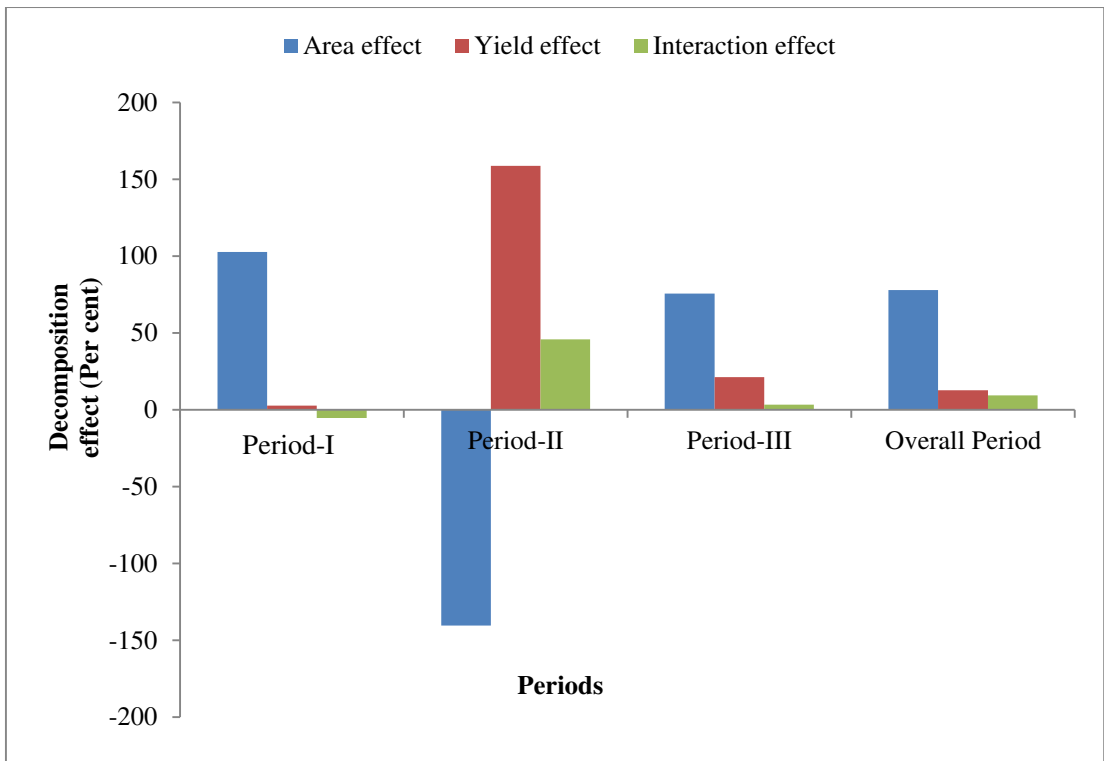
**Figure 4.23: Trend in area, production and productivity of pigeon pea in Karnataka**



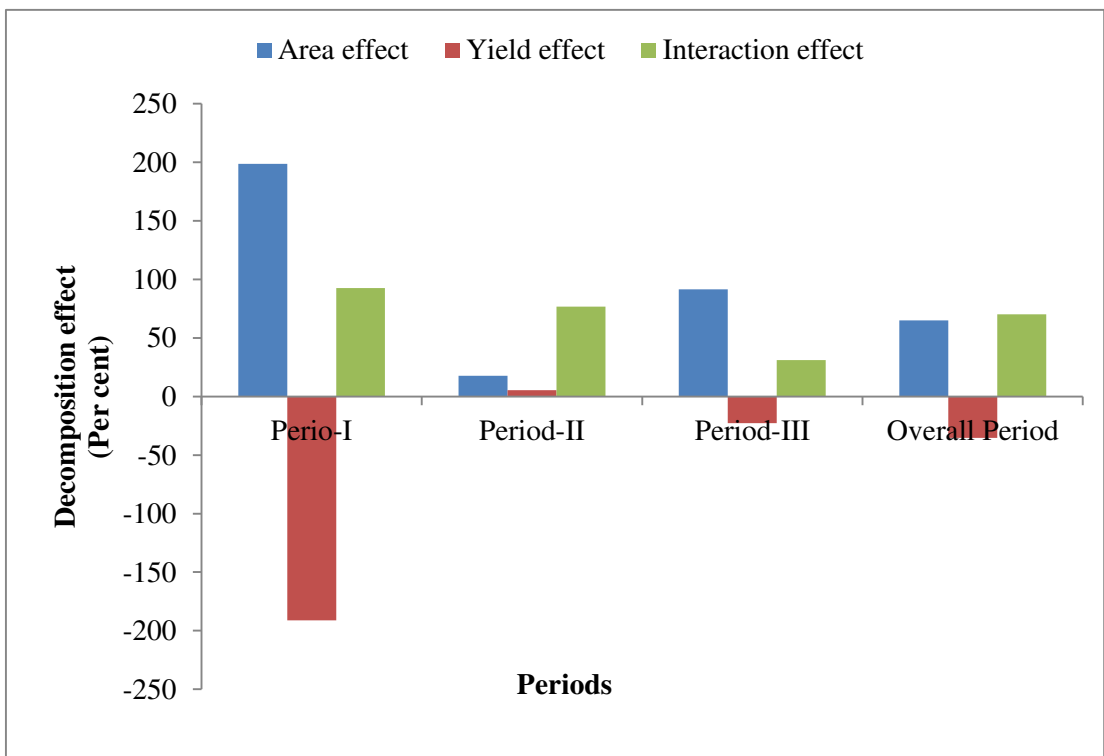
**Figure 4.24: Decomposition effect of gram in Rajasthan**



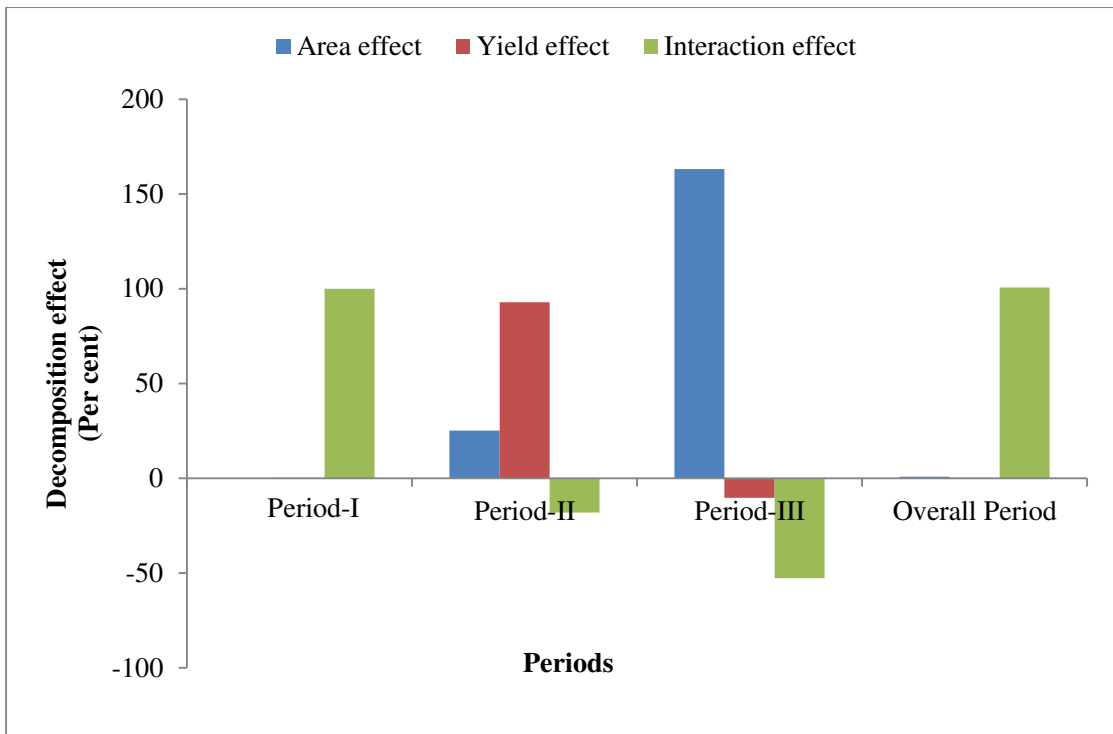
**Figure 4.25: Decomposition effect of lentil in Rajasthan**



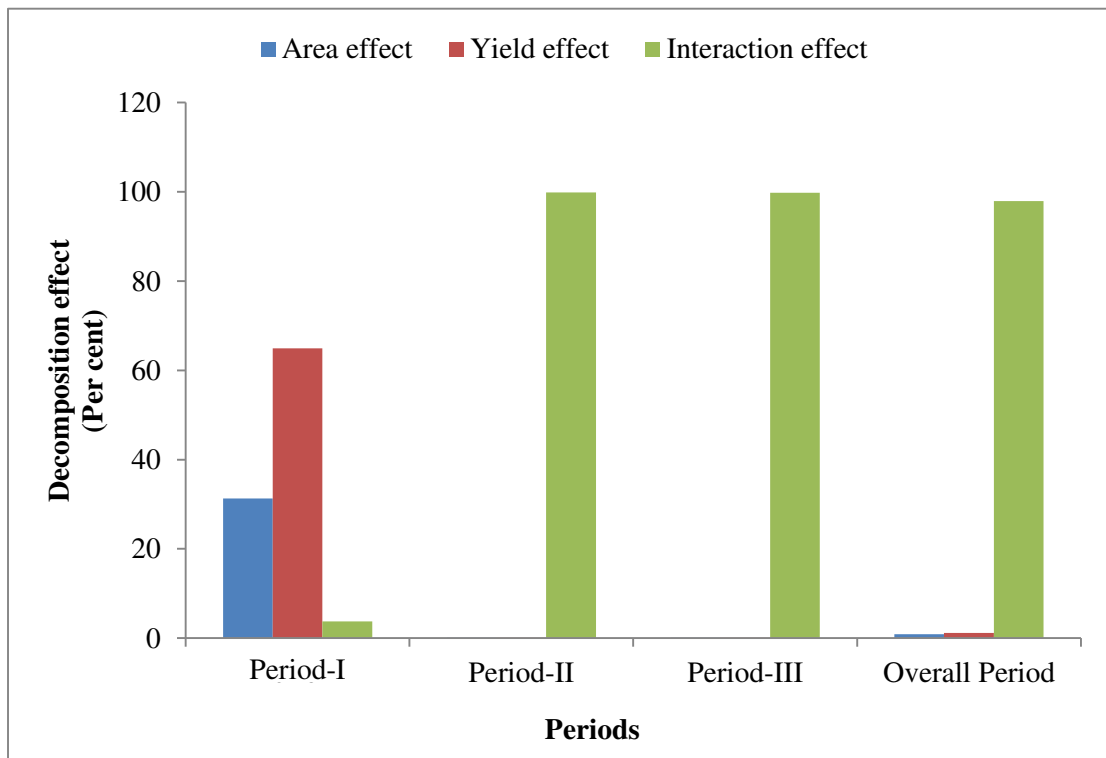
**Figure 4.26: Decomposition effect of black gram in Rajasthan**



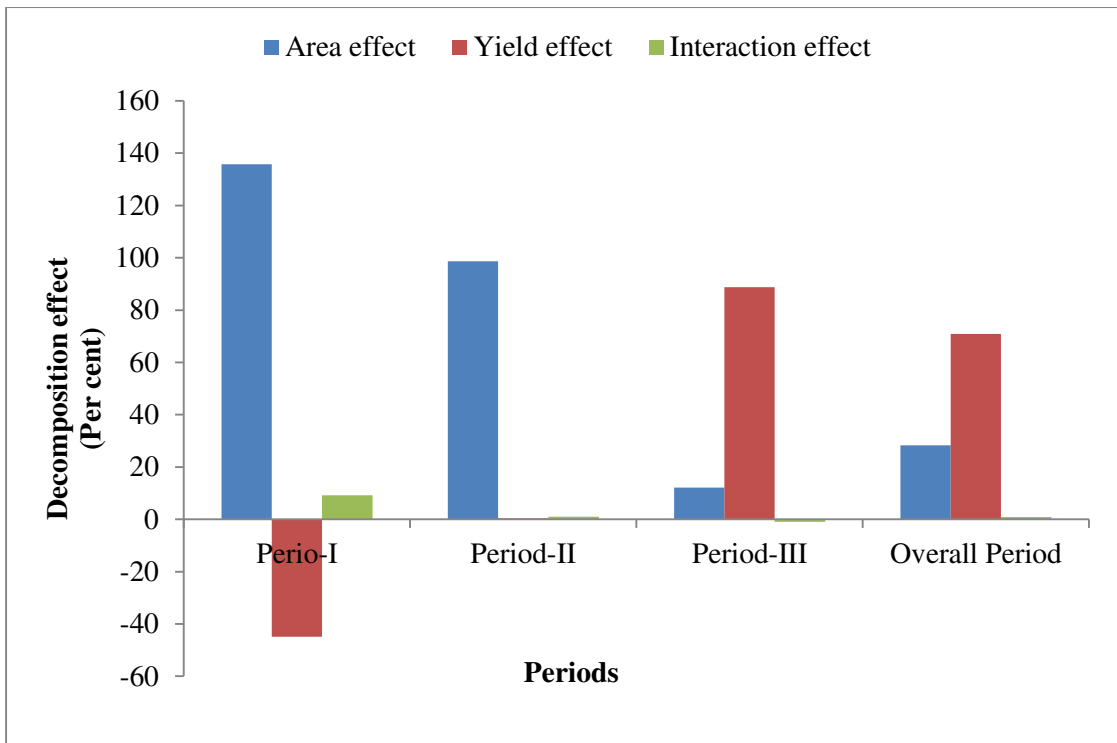
**Figure 4.27: Decomposition effect of green gram in Rajasthan**



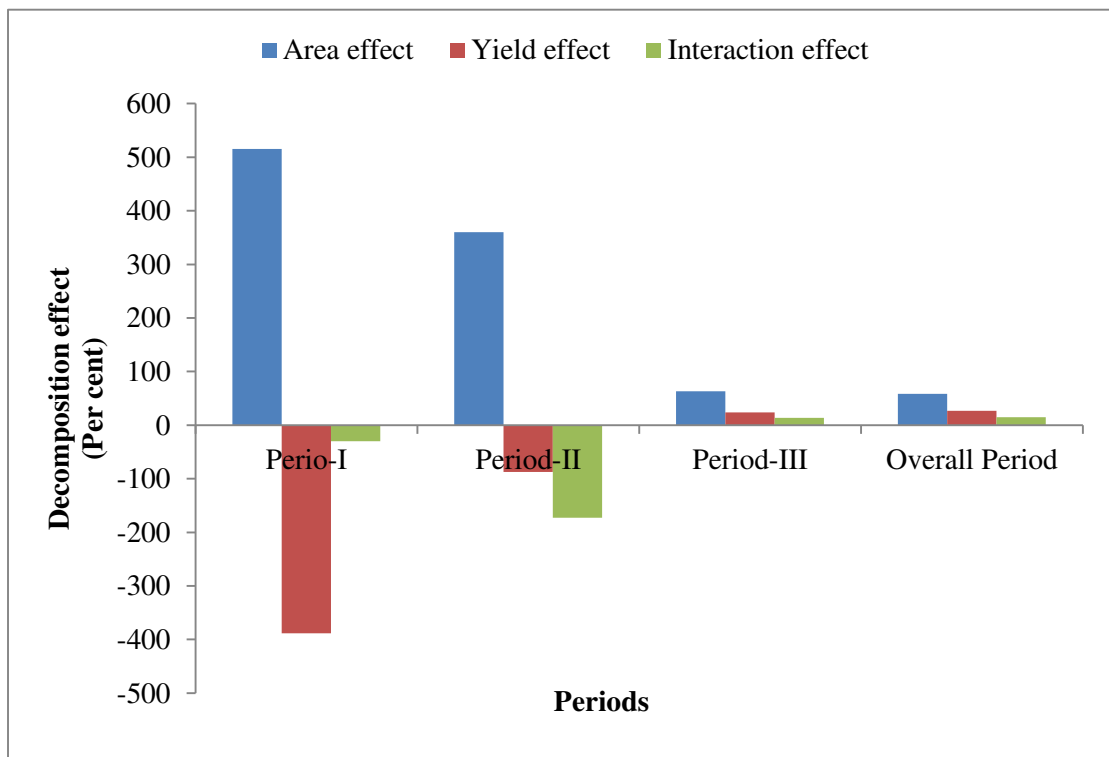
**Figure 4.28: Decomposition effect of pigeon pea in Rajasthan**



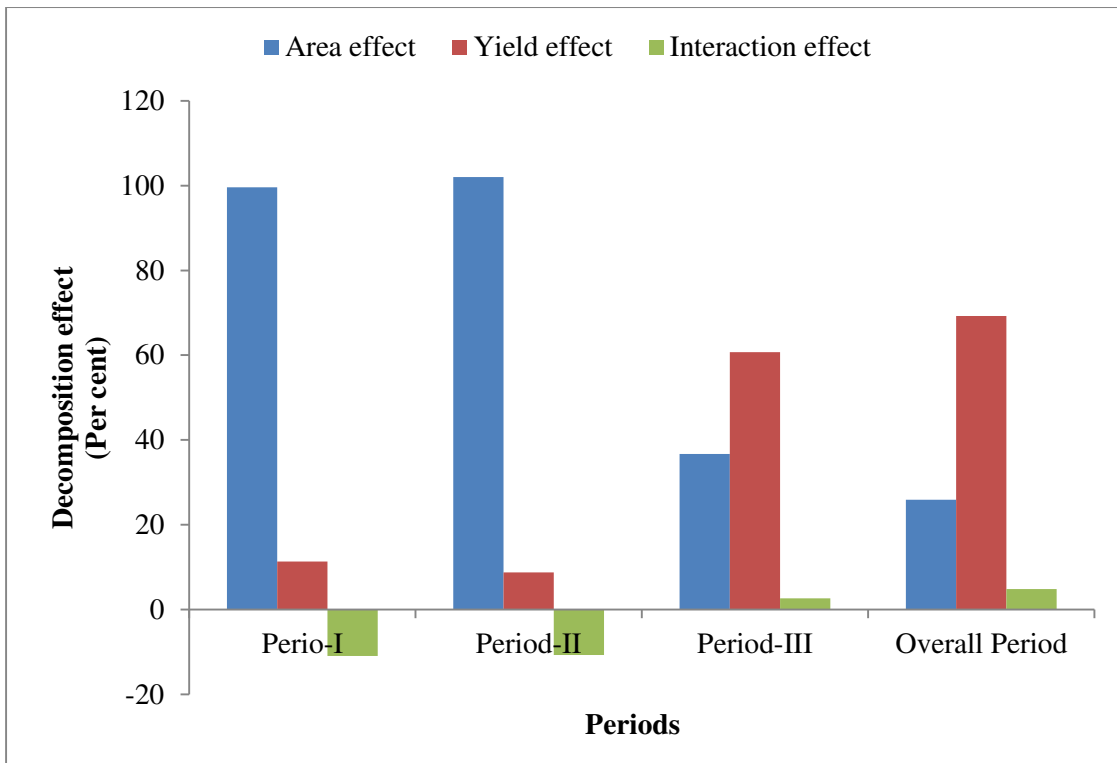
**Figure 4.29: Decomposition effect of gram in Madhya Pradesh**



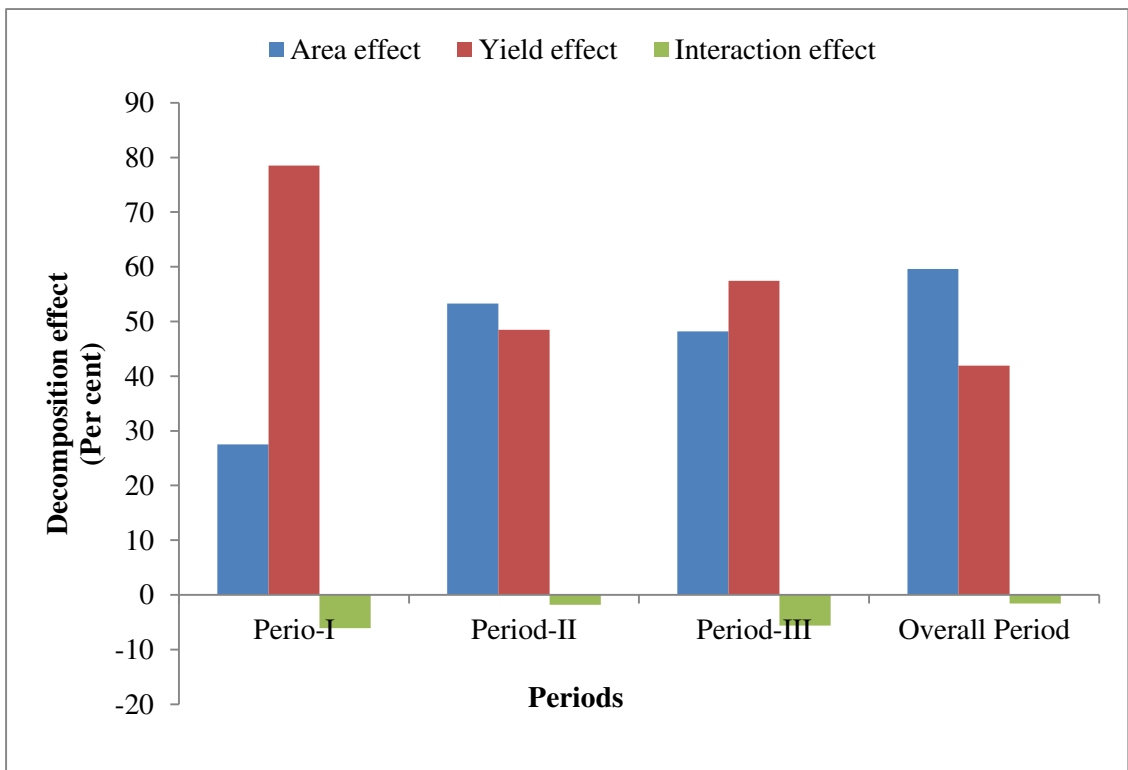
**Figure 4.30: Decomposition effect of lentil in Madhya Pradesh**



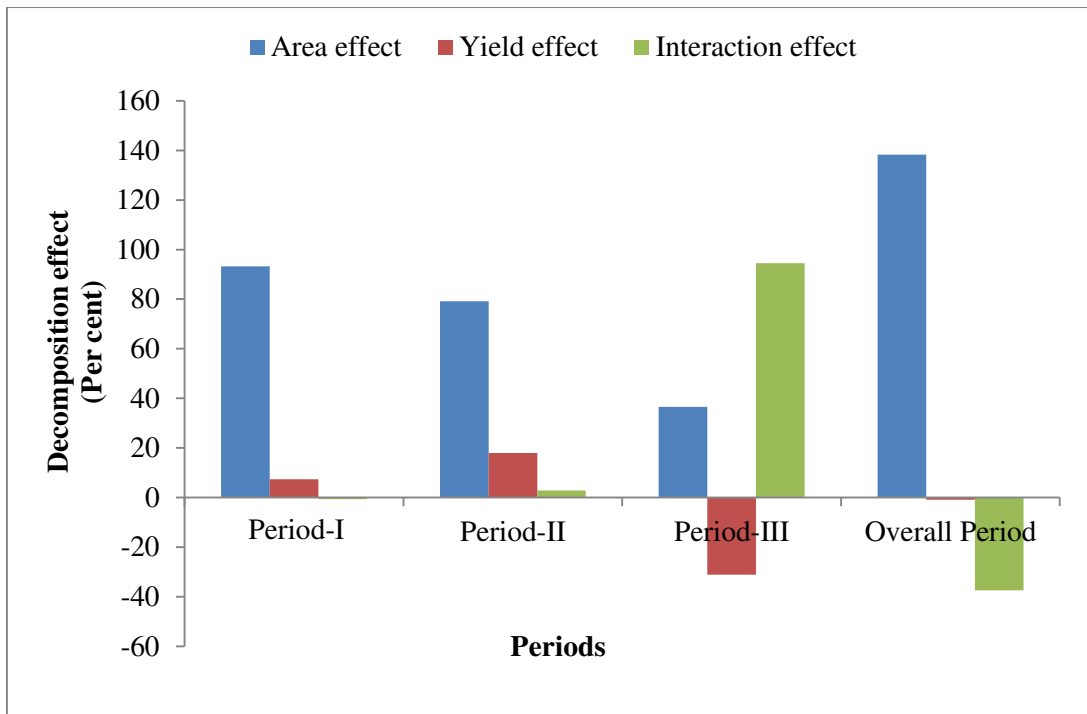
**Figure 4.31: Decomposition effect of black gram in Madhya Pradesh**



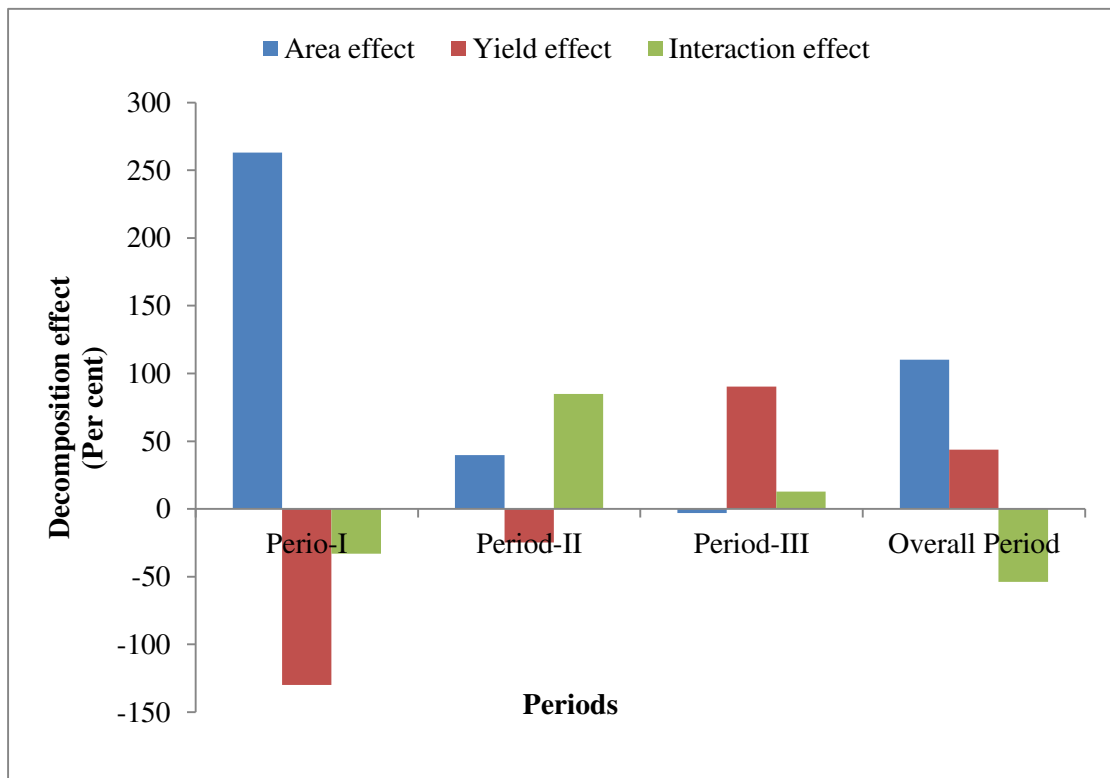
**Figure 4.32: Decomposition effect of green gram in Madhya Pradesh**



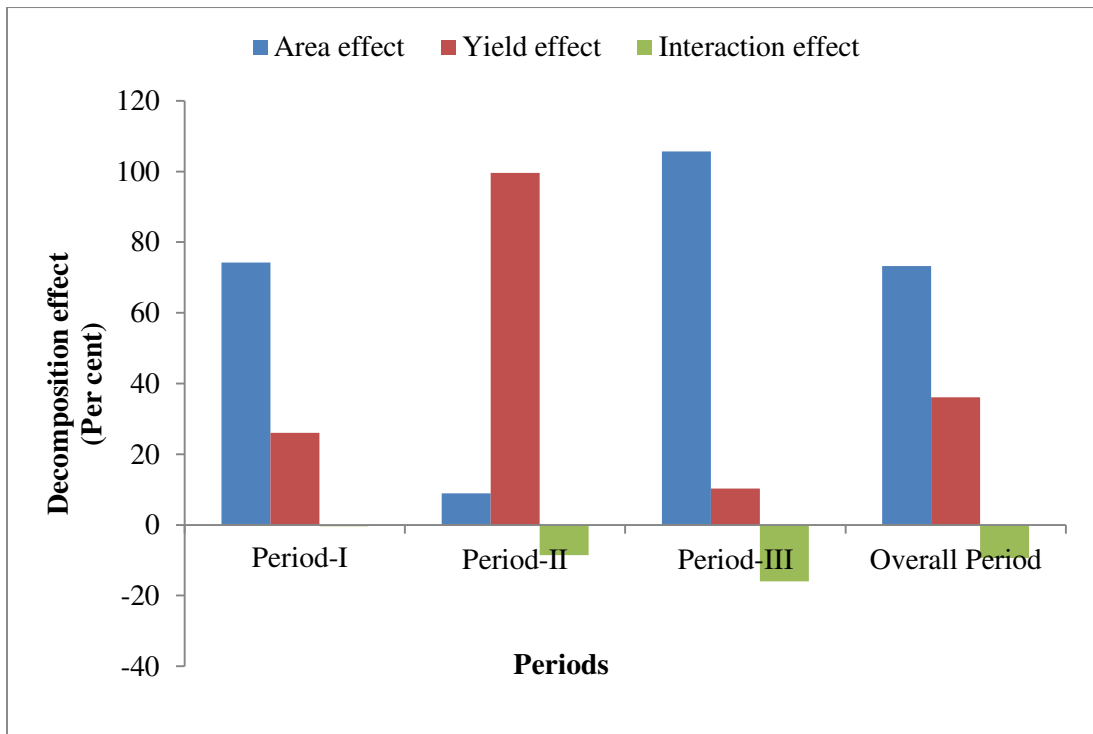
**Figure 4.33: Decomposition effect of pigeon pea in Madhya Pradesh**



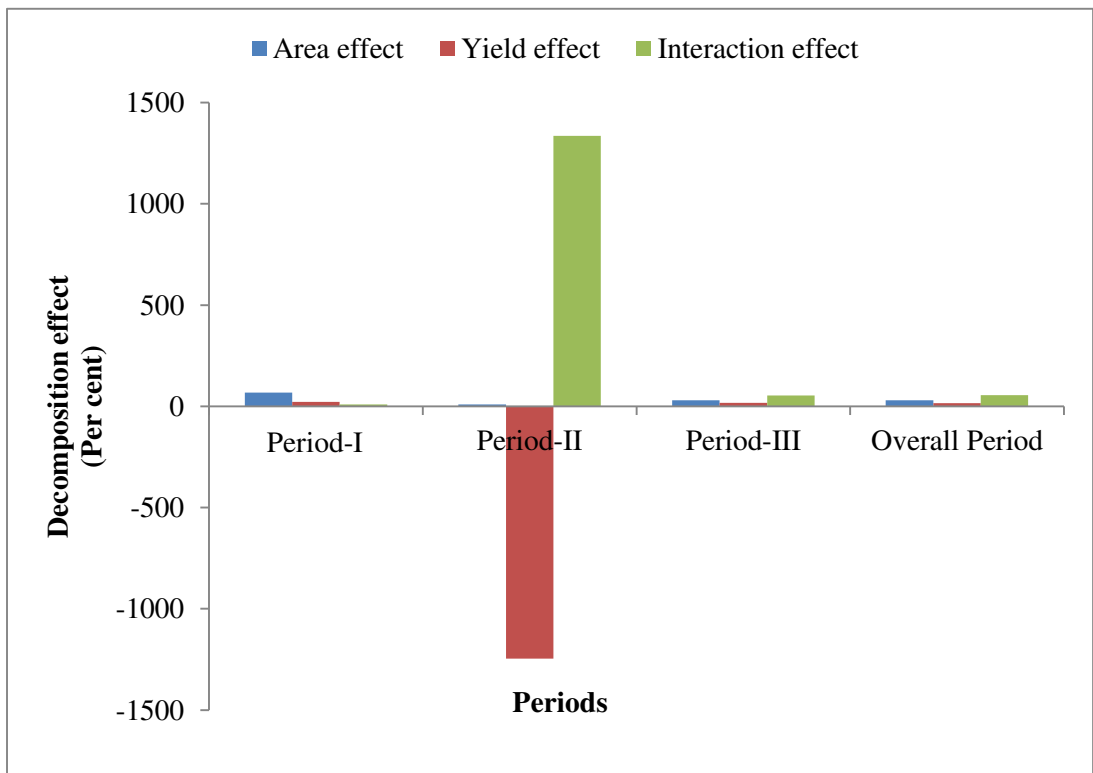
**Figure 4.34: Decomposition effect of gram in Uttar Pradesh**



**Figure 4.35: Decomposition effect of lentil in Uttar Pradesh**



**Figure 4.36: Decomposition effect of black gram in Uttar Pradesh**



**Figure 4.37: Decomposition effect of green gram in Uttar Pradesh**

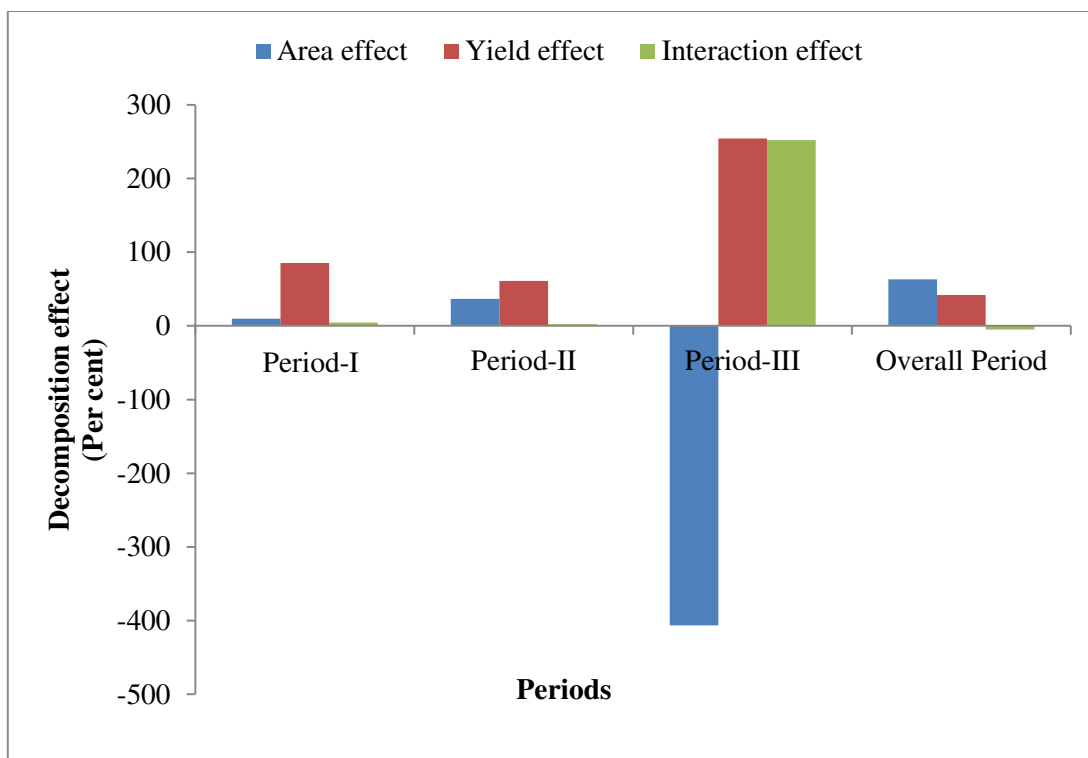


Figure 4.38: Decomposition effect of pigeon pea in Uttar Pradesh

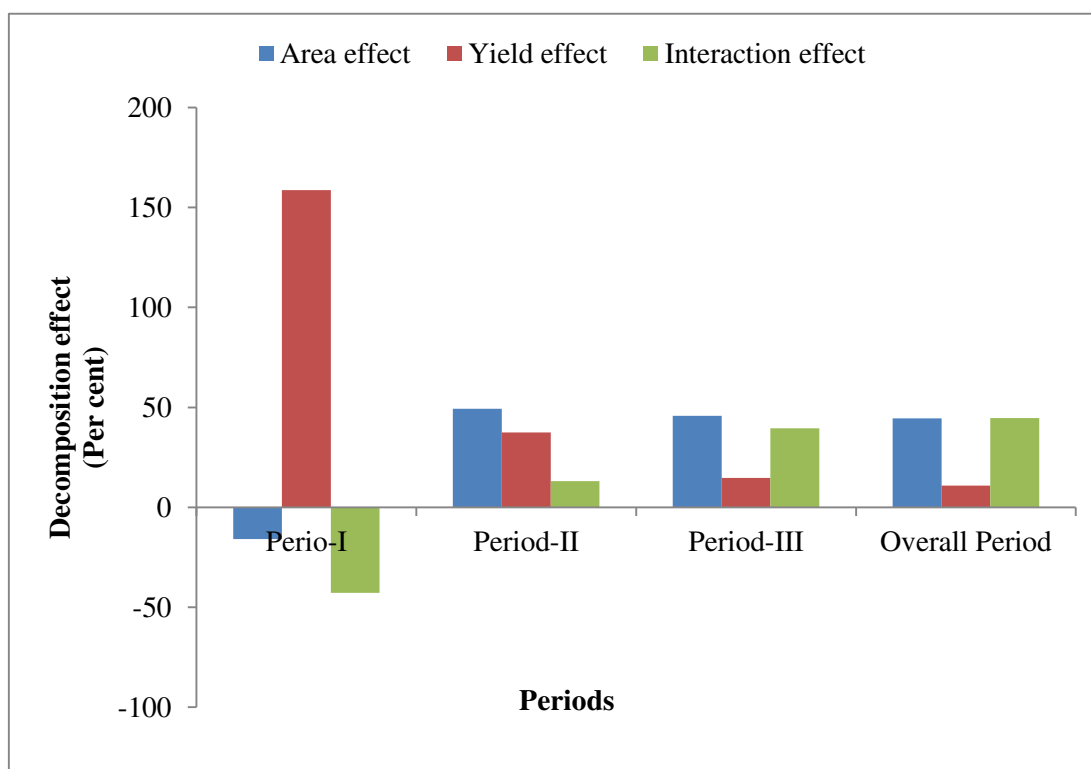
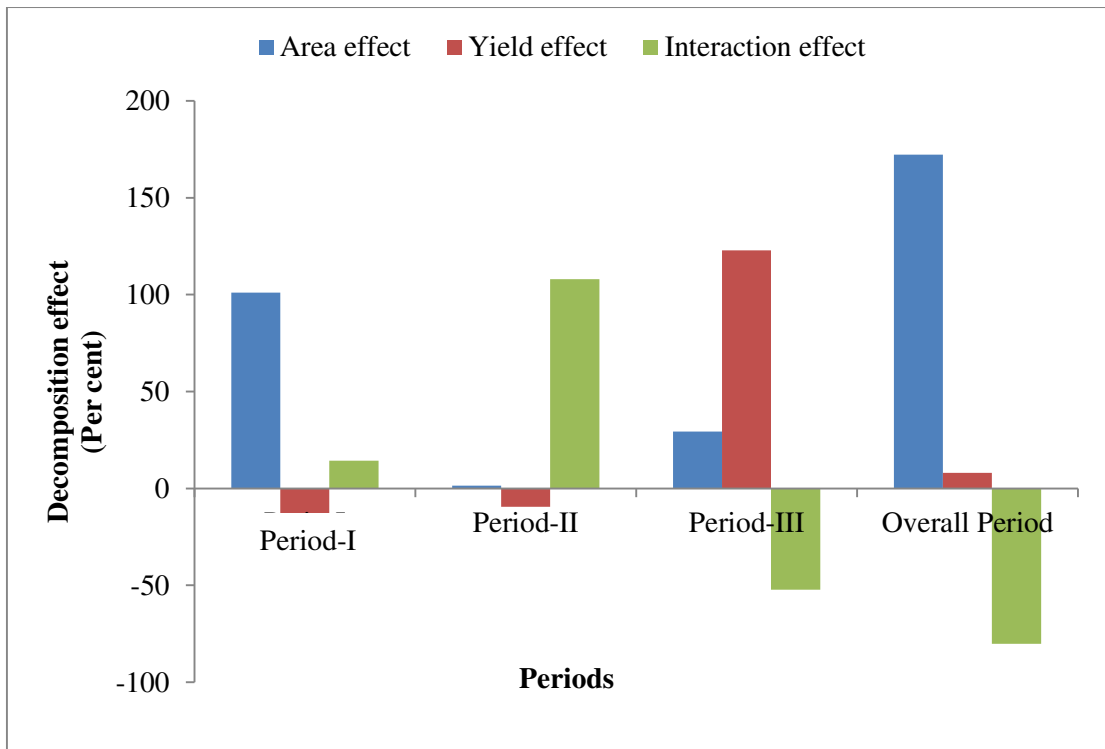
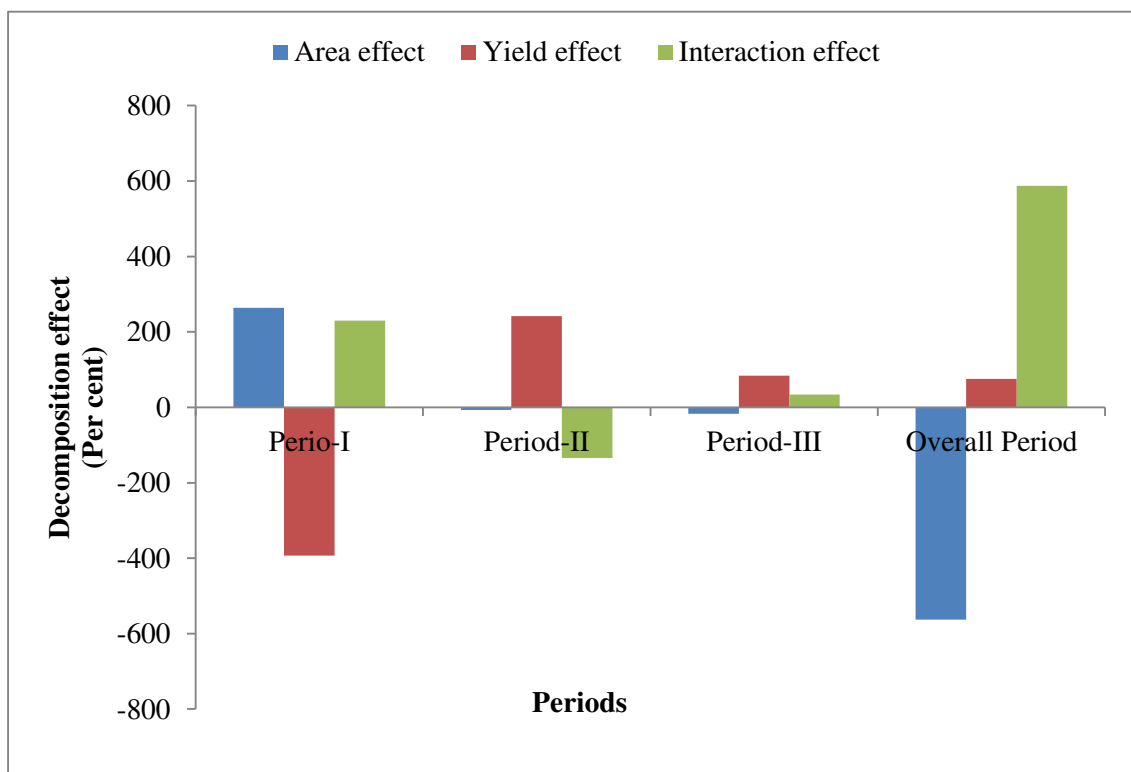


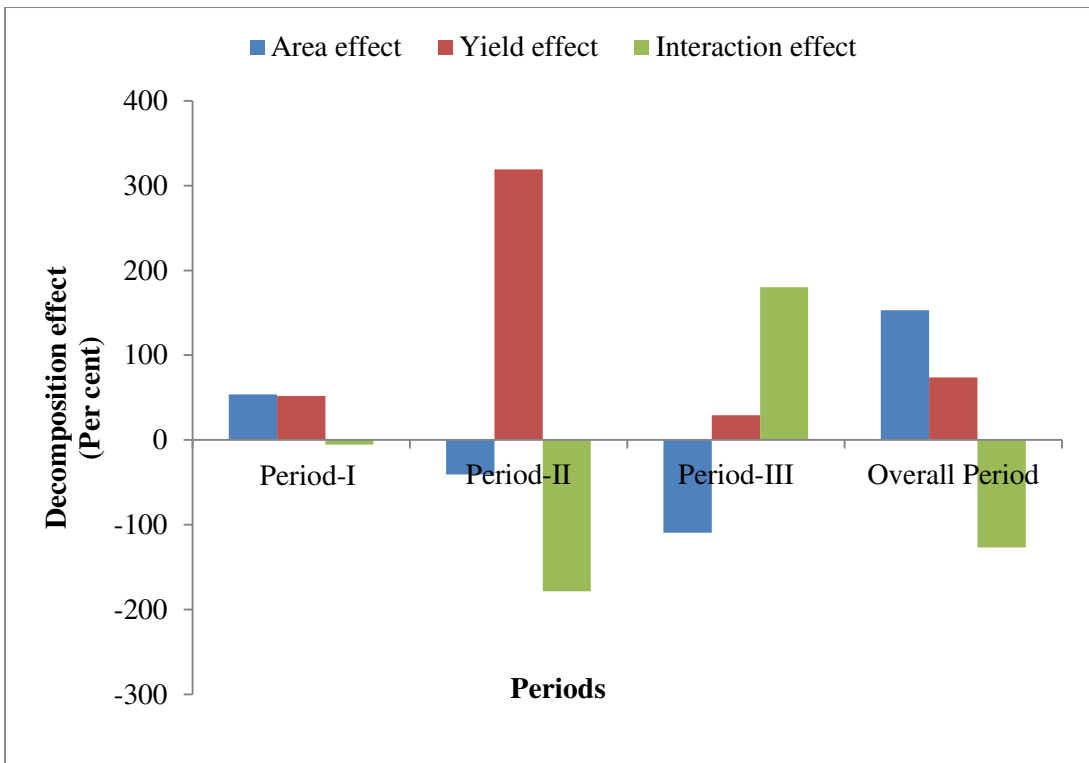
Figure 4.39: Decomposition effect of gram in Maharashtra



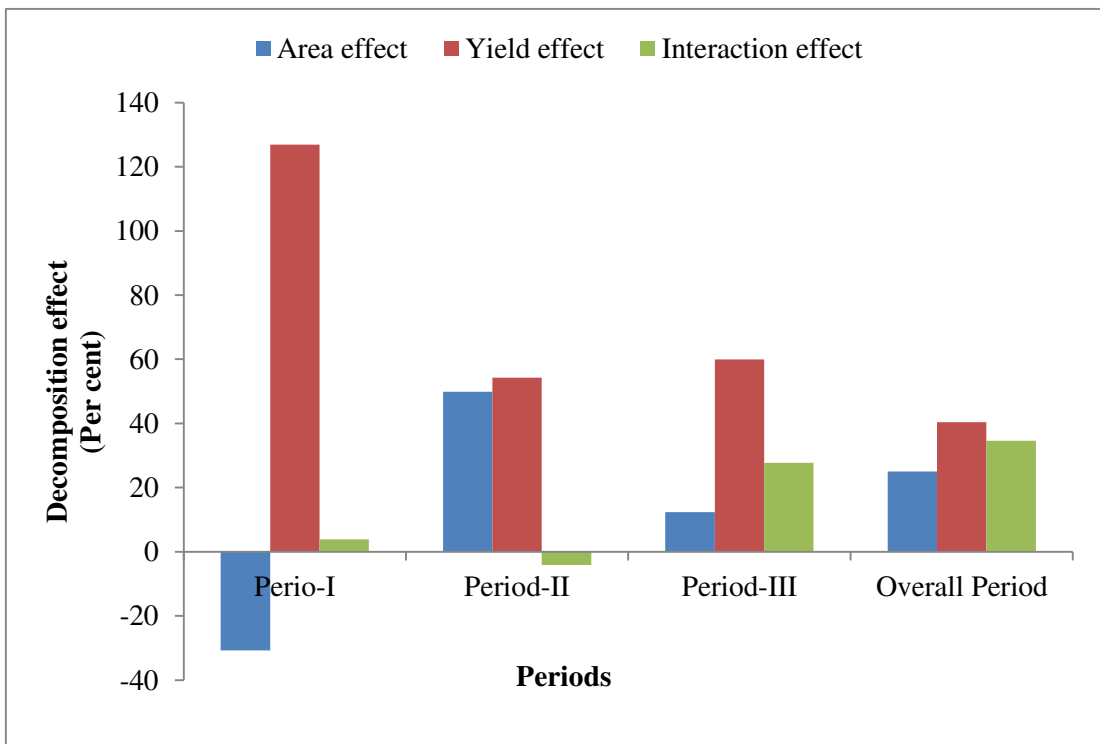
**Figure 4.40: Decomposition effect of lentil in Maharashtra**



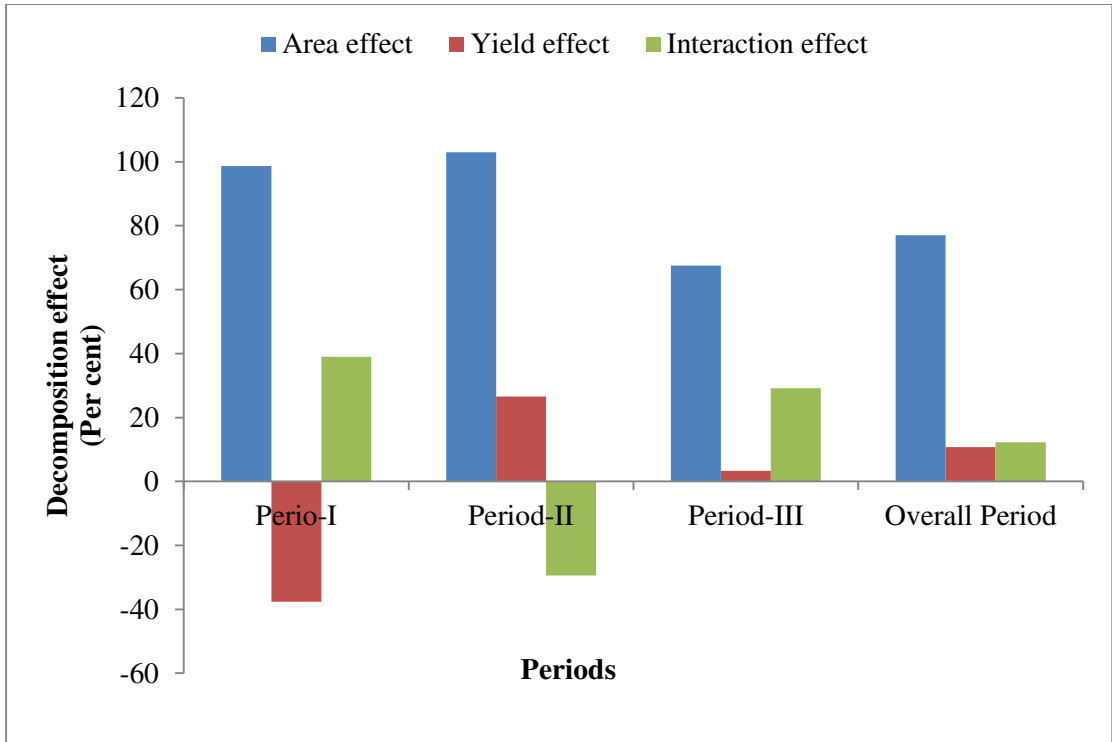
**Figure 4.41: Decomposition effect of black gram in Maharashtra**



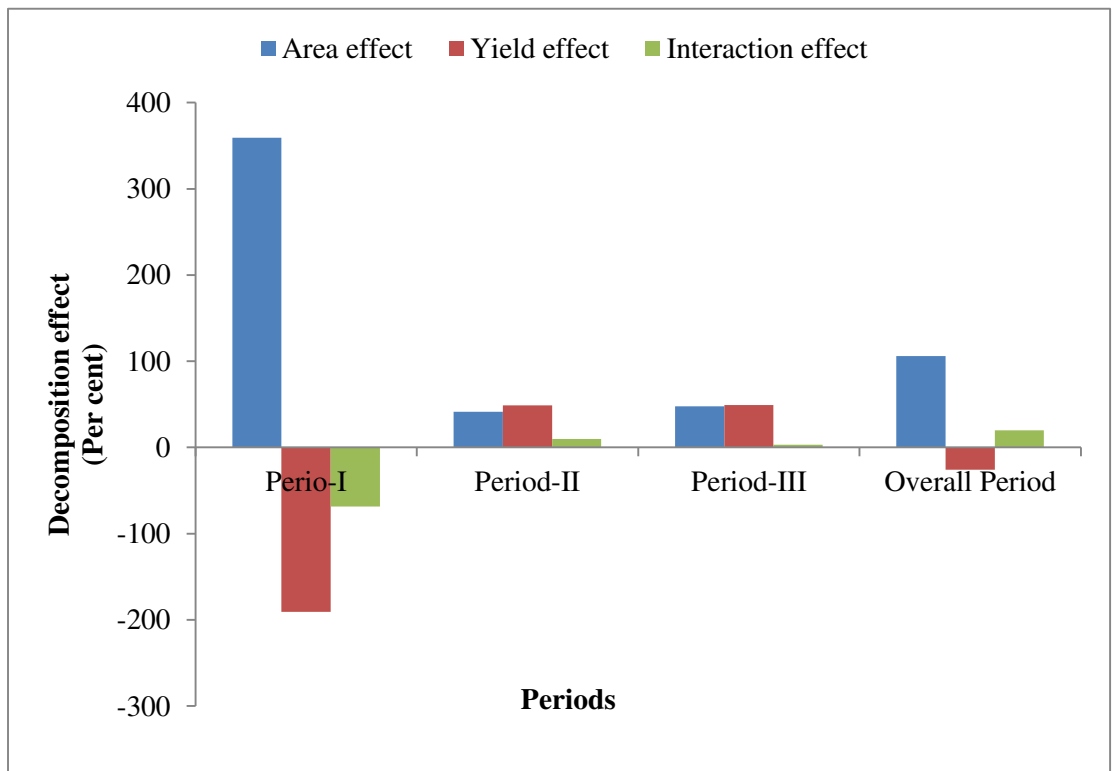
**Figure 4.42: Decomposition effect of green gram in Maharashtra**



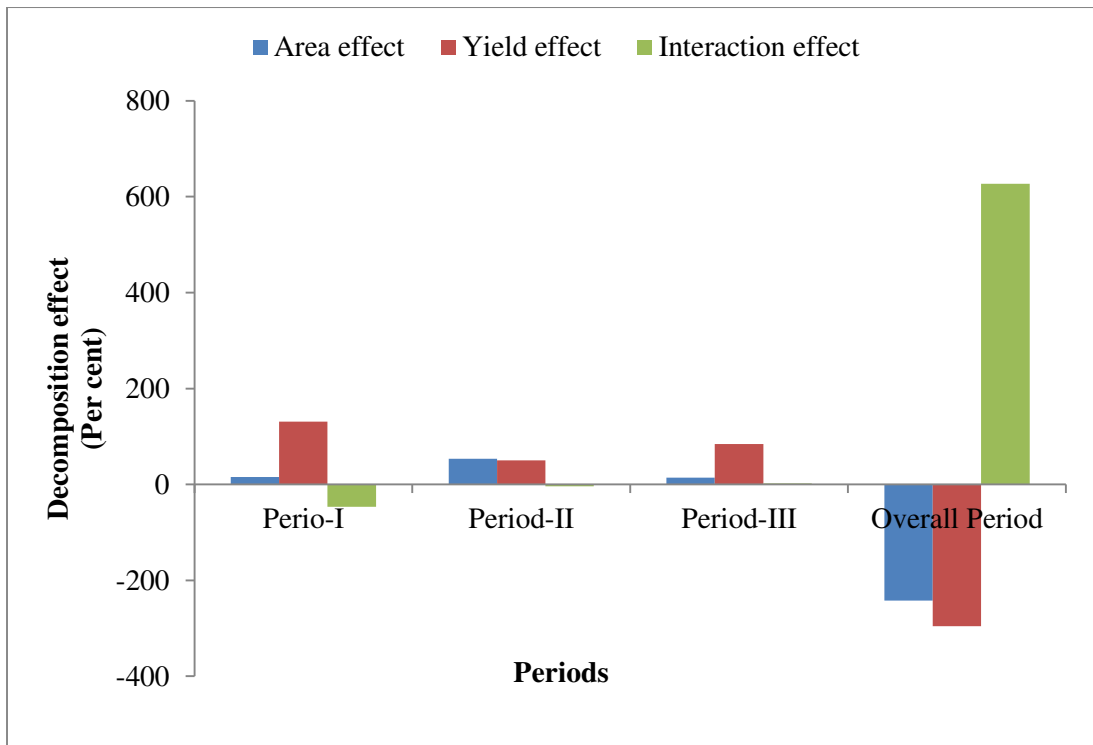
**Figure 4.43: Decomposition effect of pigeon pea in Maharashtra**



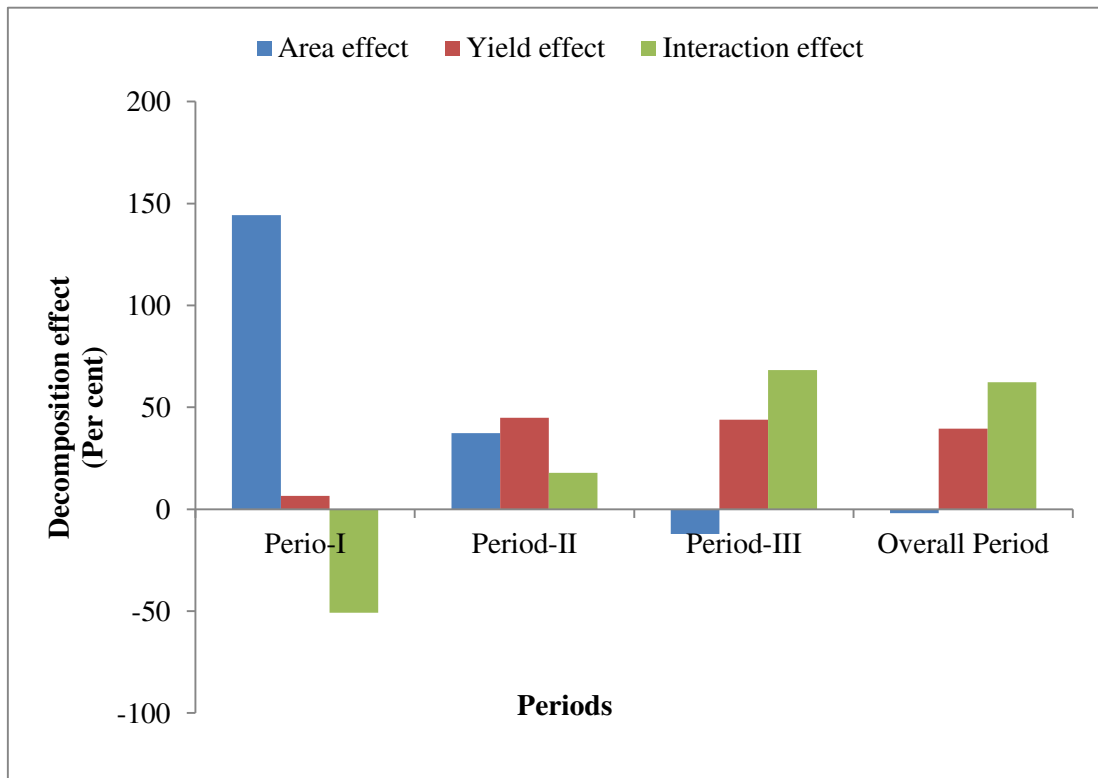
**Figure 4.44: Decomposition effect of gram in Karnataka**



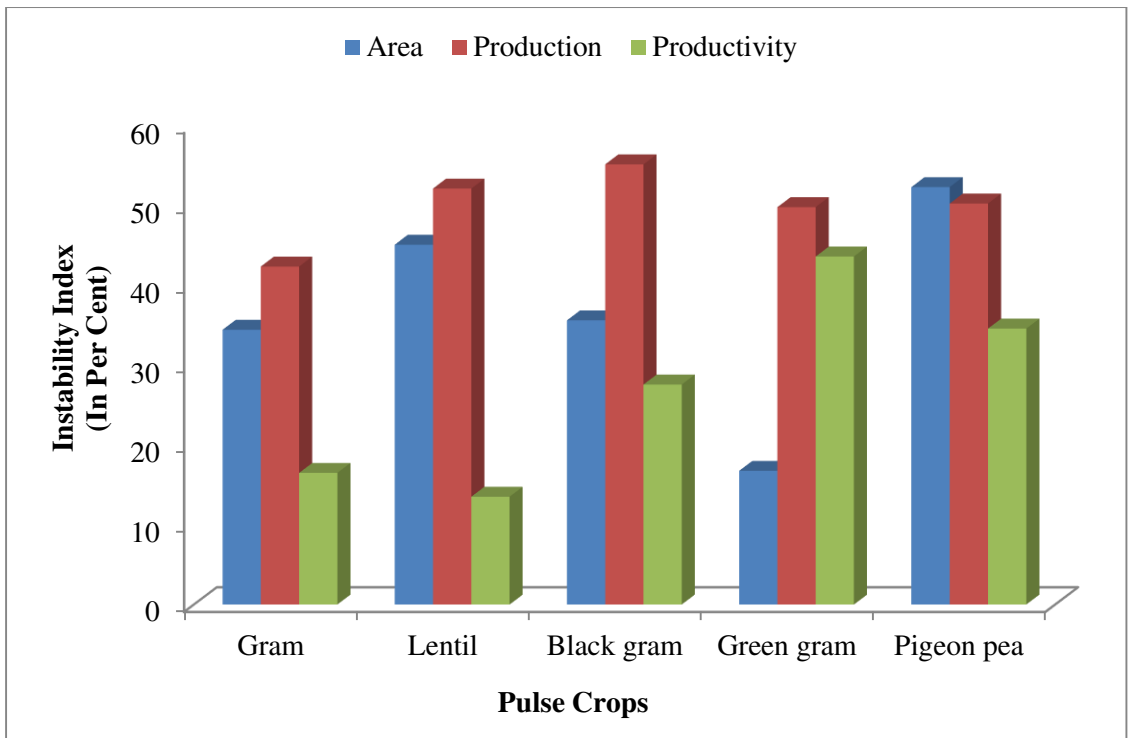
**Figure 4.45: Decomposition effect of black gram in Karnataka**



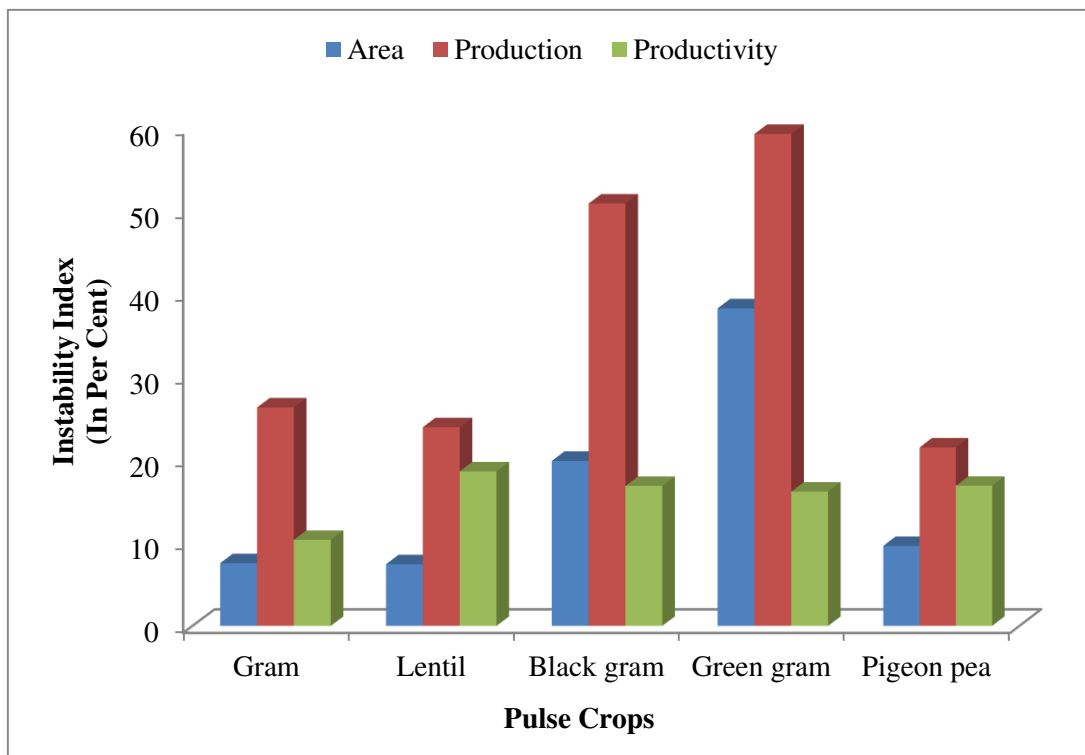
**Figure 4.46: Decomposition effect of green gram in Karnataka**



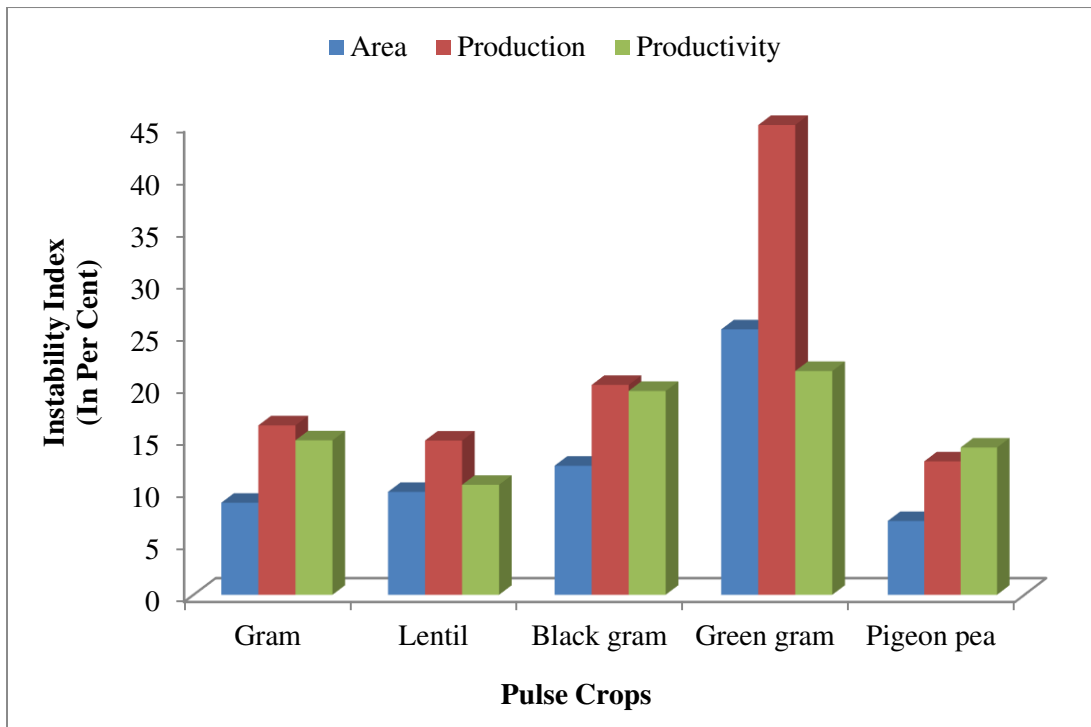
**Figure 4.47: Decomposition effect of pigeon pea in Karnataka**



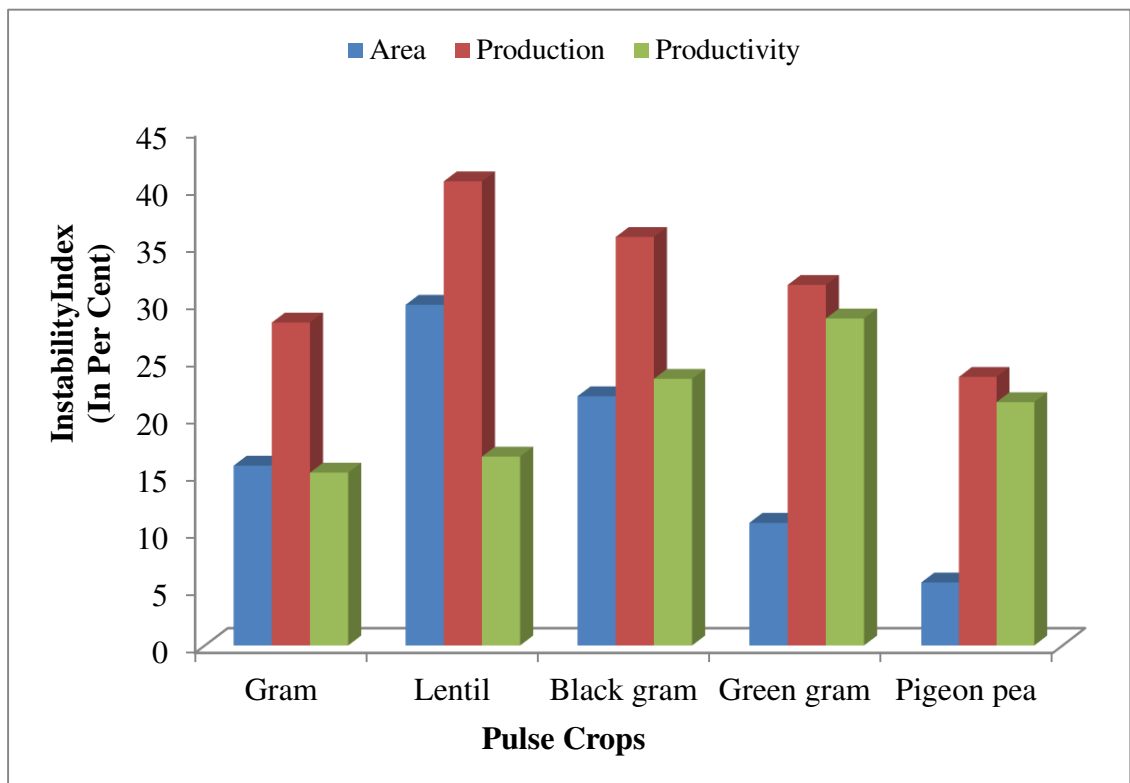
**Figure 4.48: Instability in area, production and productivity of Major pulse crops in Rajasthan**



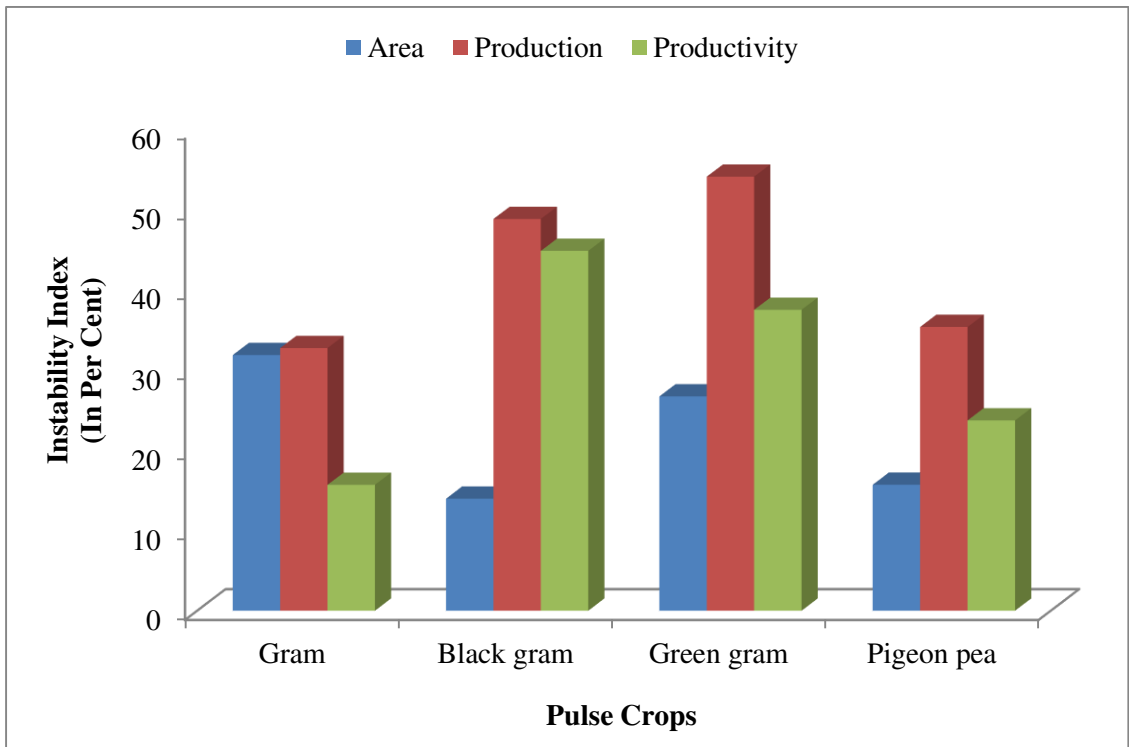
**Figure 4.49: Instability in area, production and productivity of Major pulse crops in Madhya Pradesh**



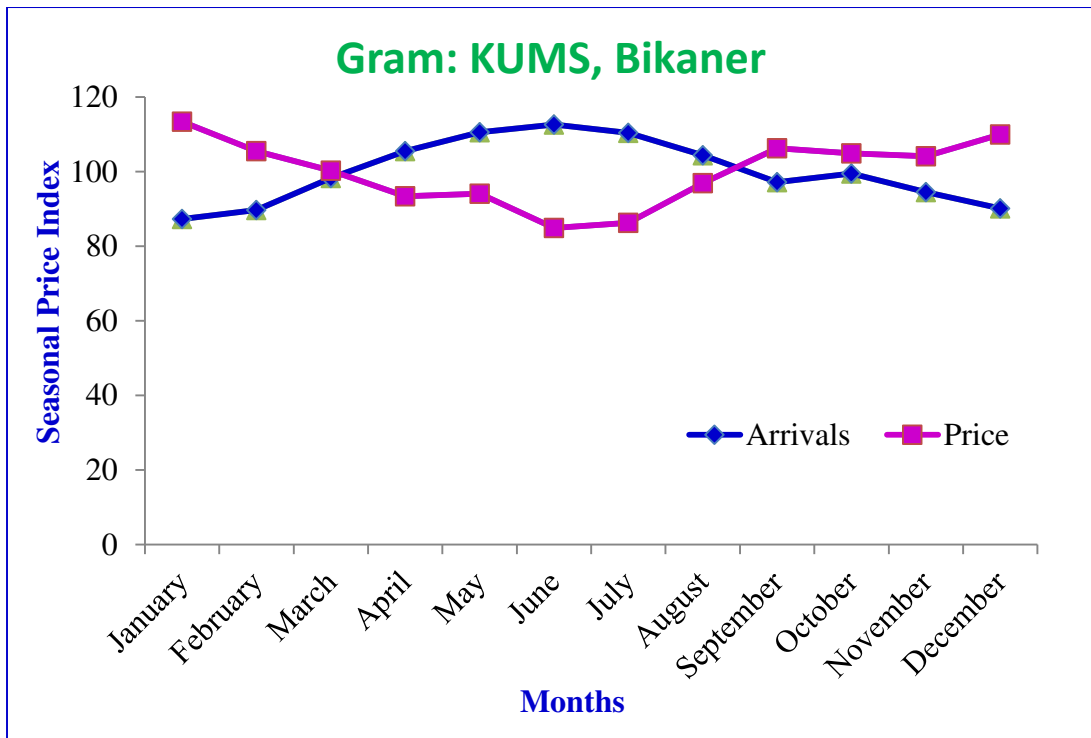
**Figure 4.50: Instability in area, production and productivity of Major pulse crops in Uttar Pradesh**



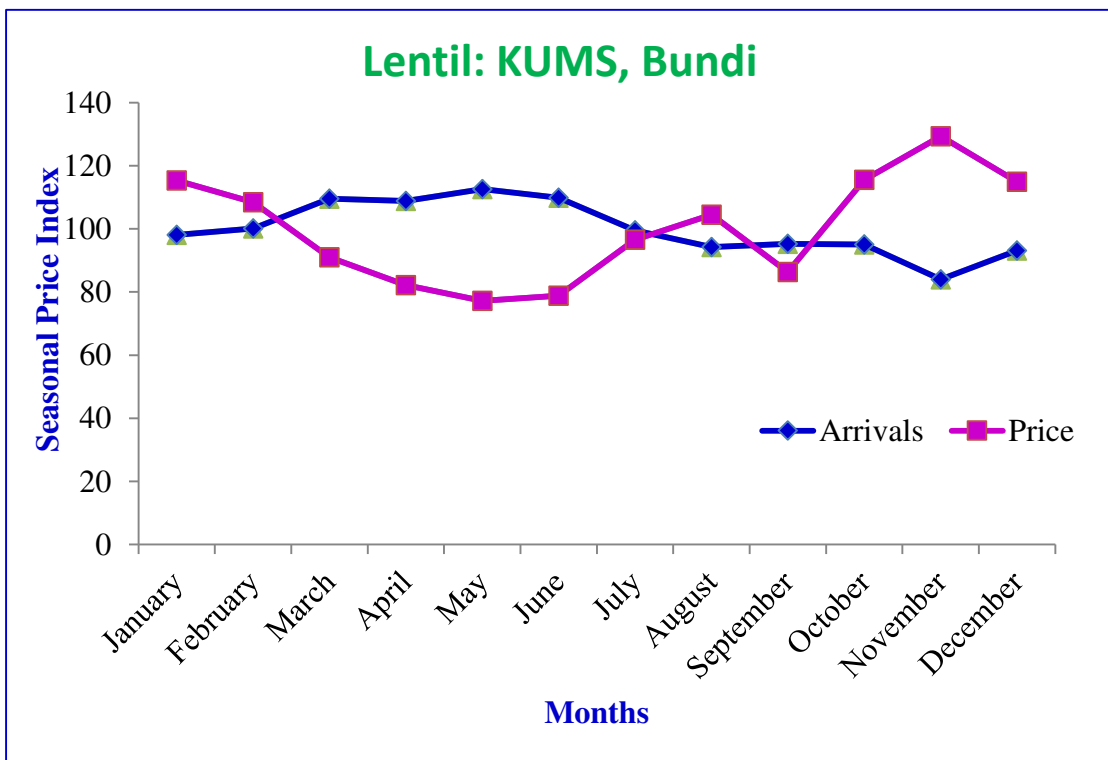
**Figure 4.51: Instability in area, production and productivity of Major pulse crops in Maharashtra**



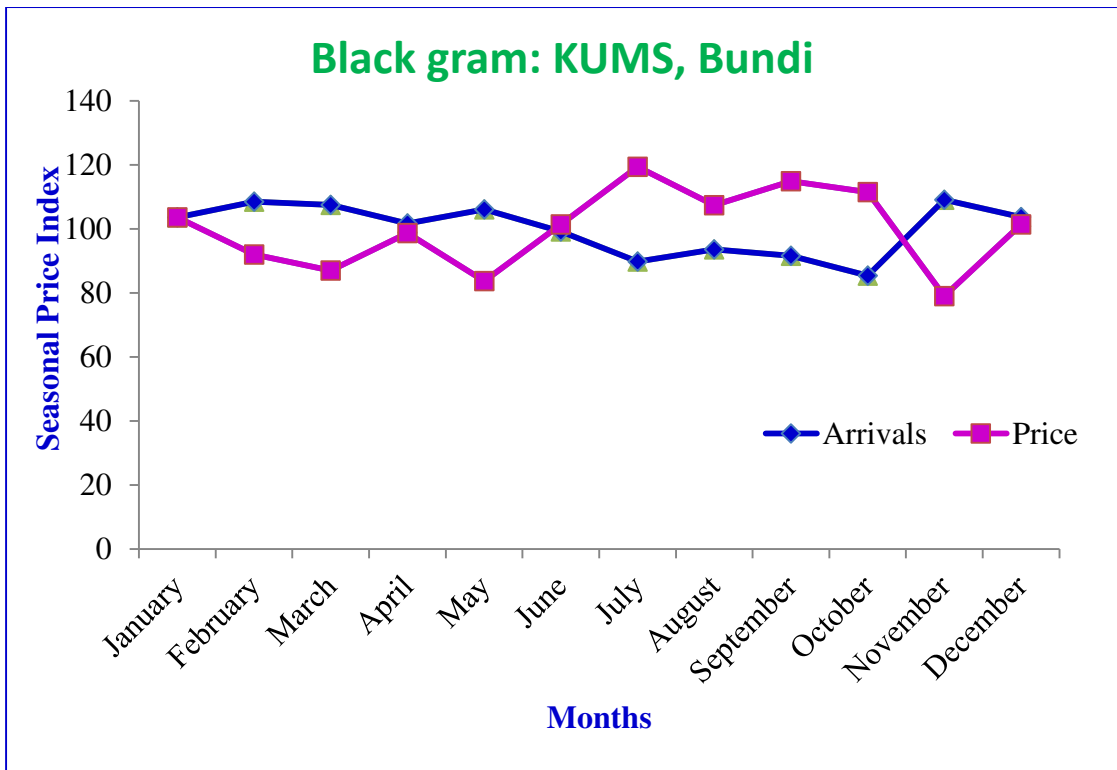
**Figure 4.52: Instability in area, production and productivity of Major pulse crops in Karnataka**



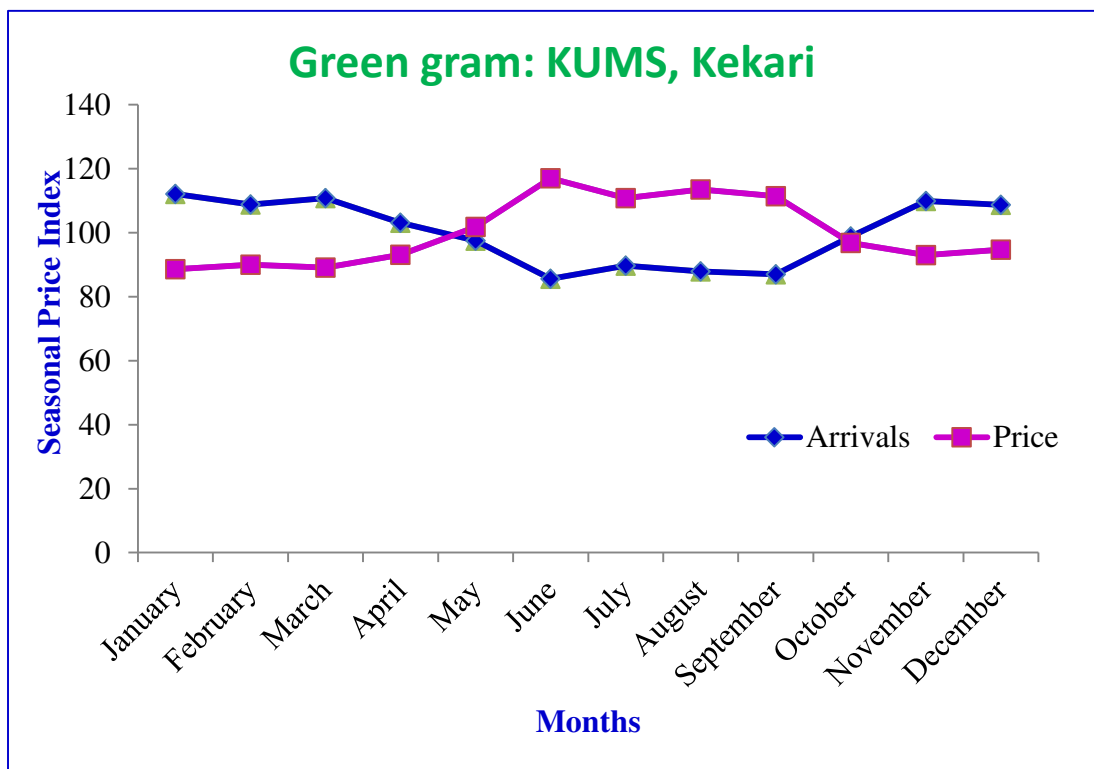
**Figure 4.53: Seasonal price index of monthly arrivals and prices of Gram in KUMS, Bikaner (2008-2017)**



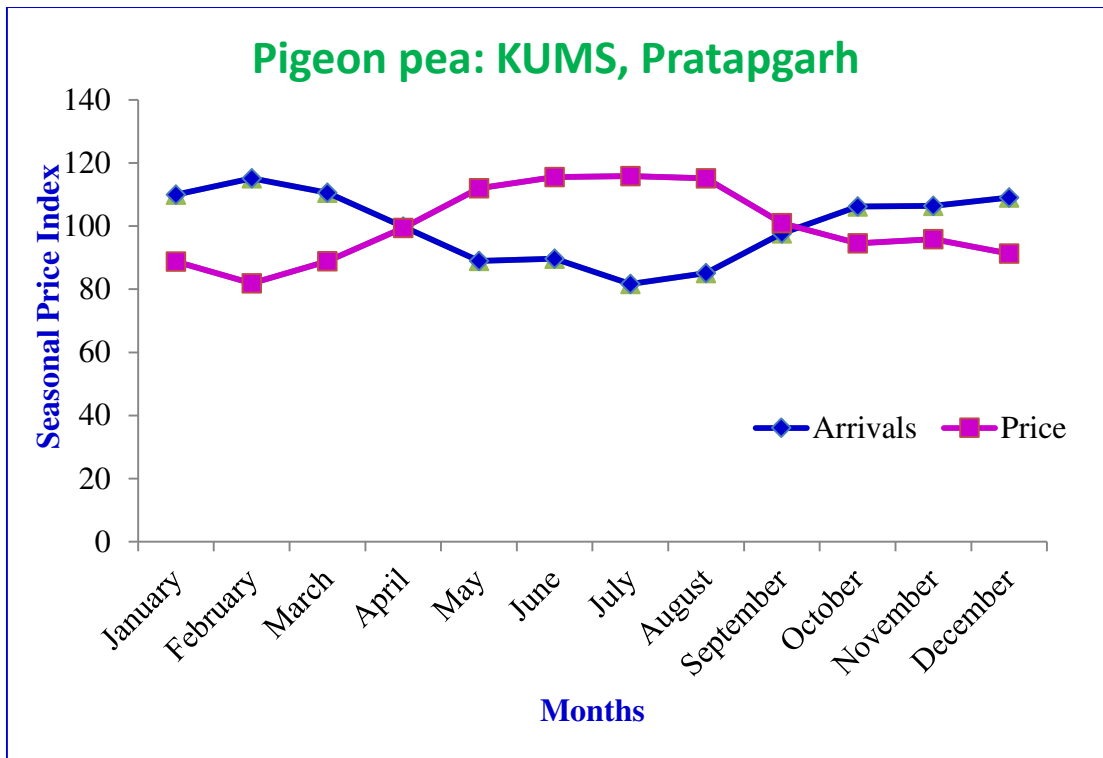
**Figure 4.54: Seasonal index of monthly arrivals and prices of Lentil in KUMS, Bundi (2008-2017)**



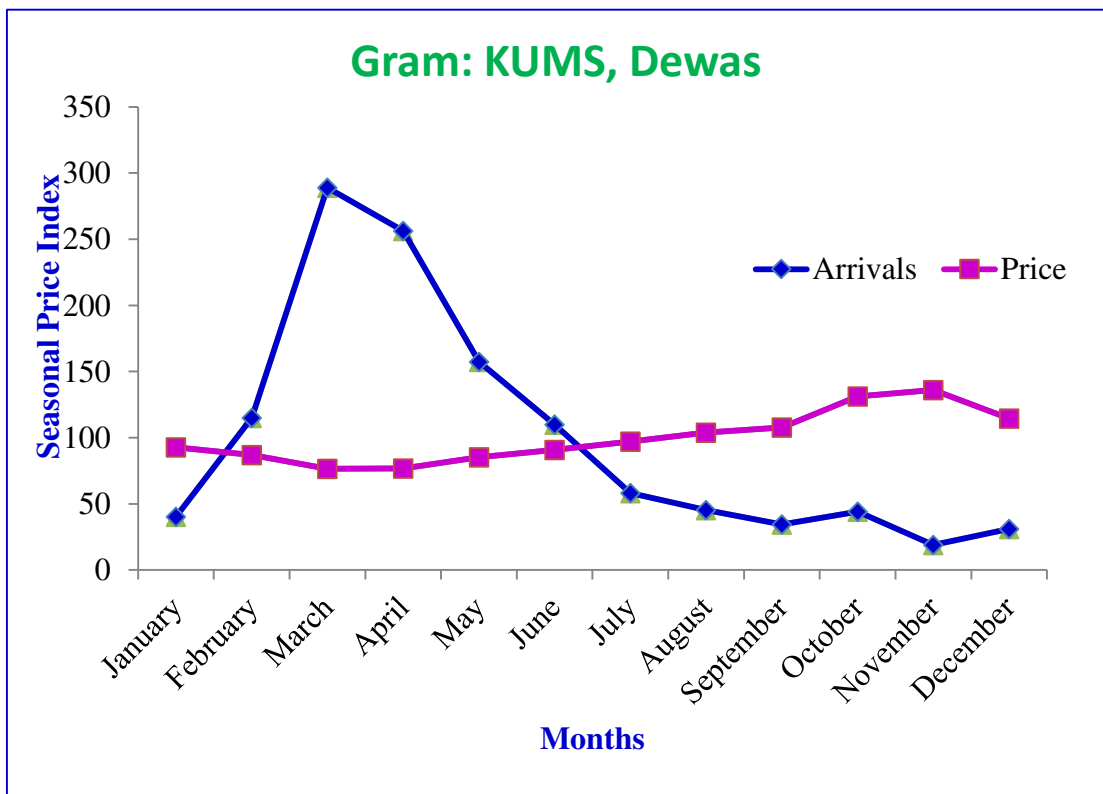
**Figure 4.55: Seasonal price index of monthly arrivals and prices of Black gram in KUMS, Bundi (2008-2017)**



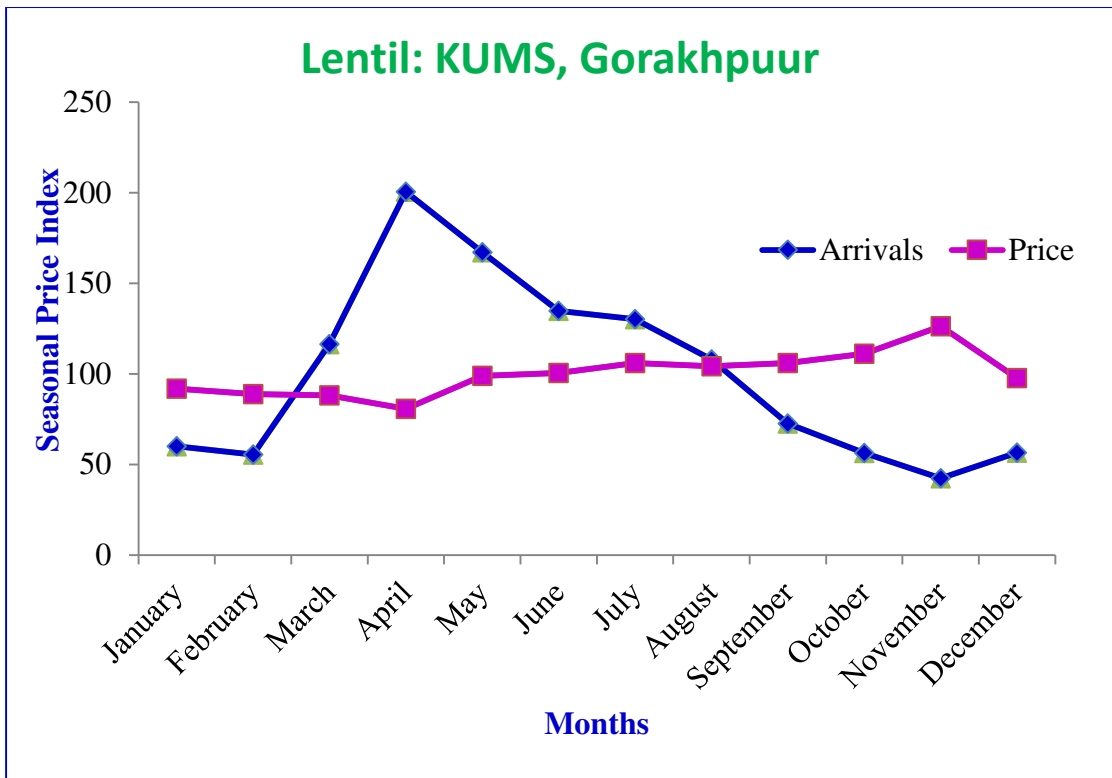
**Figure 4.56: Seasonal price index of monthly arrivals and prices of Green gram in KUMS, Kekari (2008-2017)**



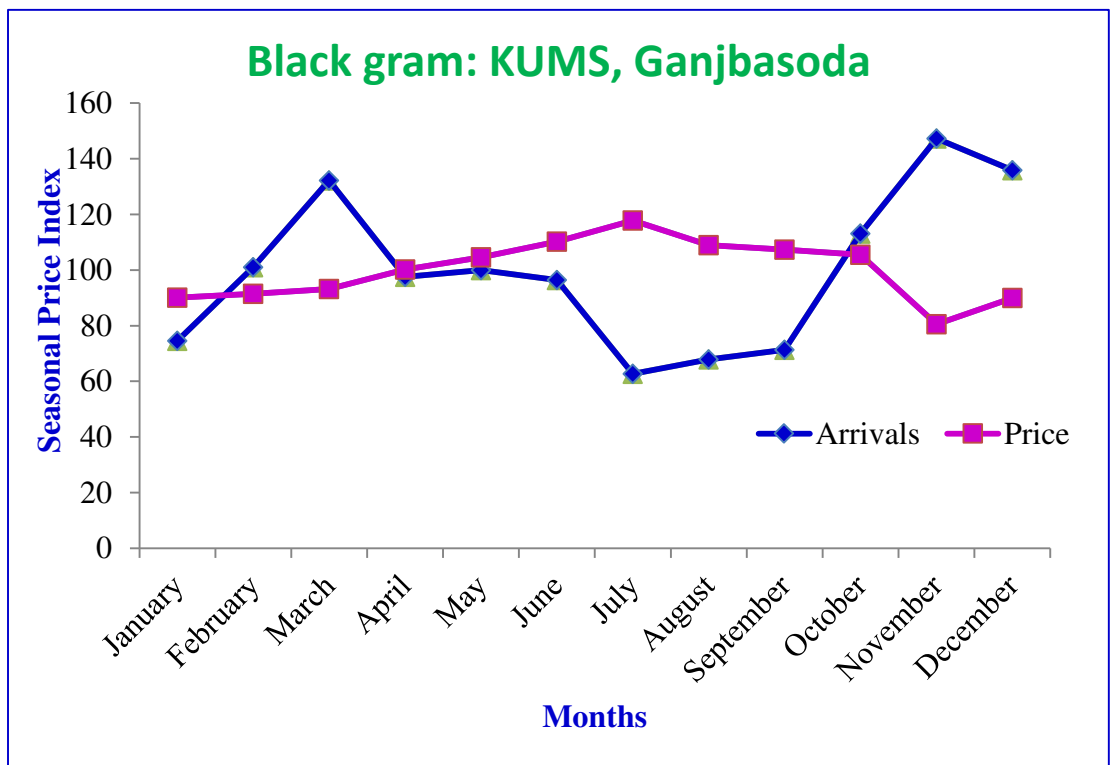
**Figure 4.57: Seasonal price index of monthly arrivals and prices of Pigeon pea in KUMS, Pratapgarh (2008-2017)**



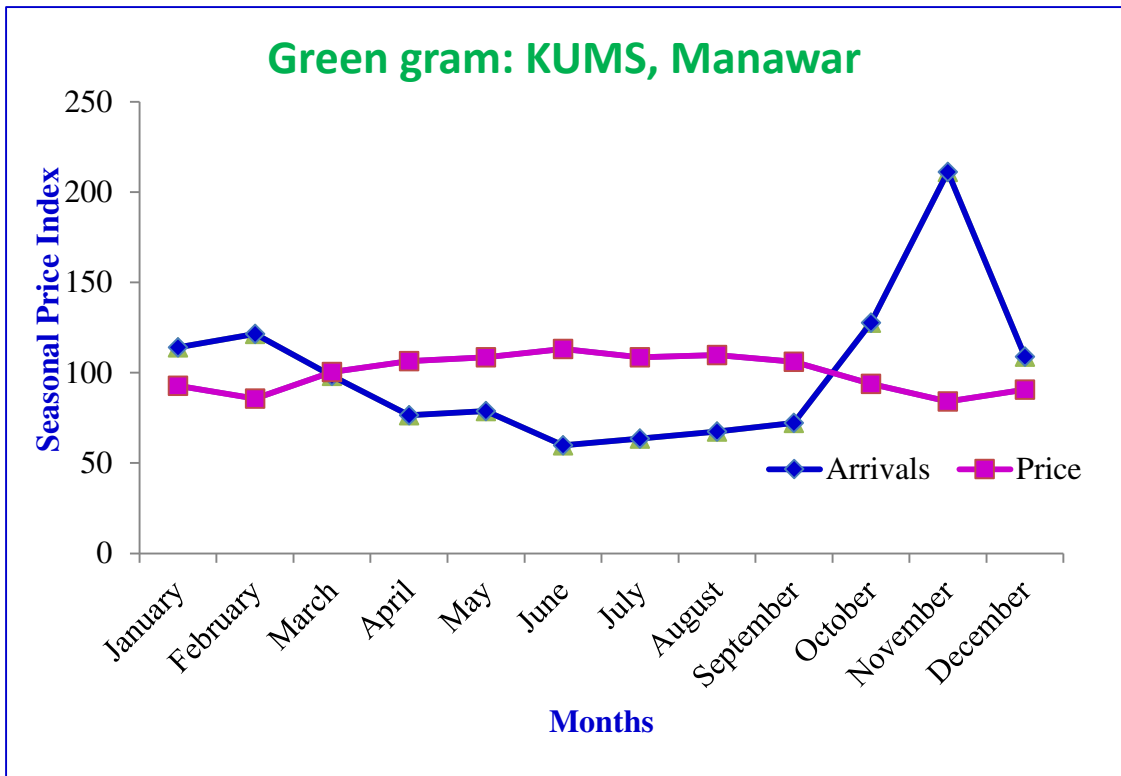
**Figure 4.58: Seasonal price index of monthly arrivals and prices of Gram in KUMS, Dewas (2008-2017)**



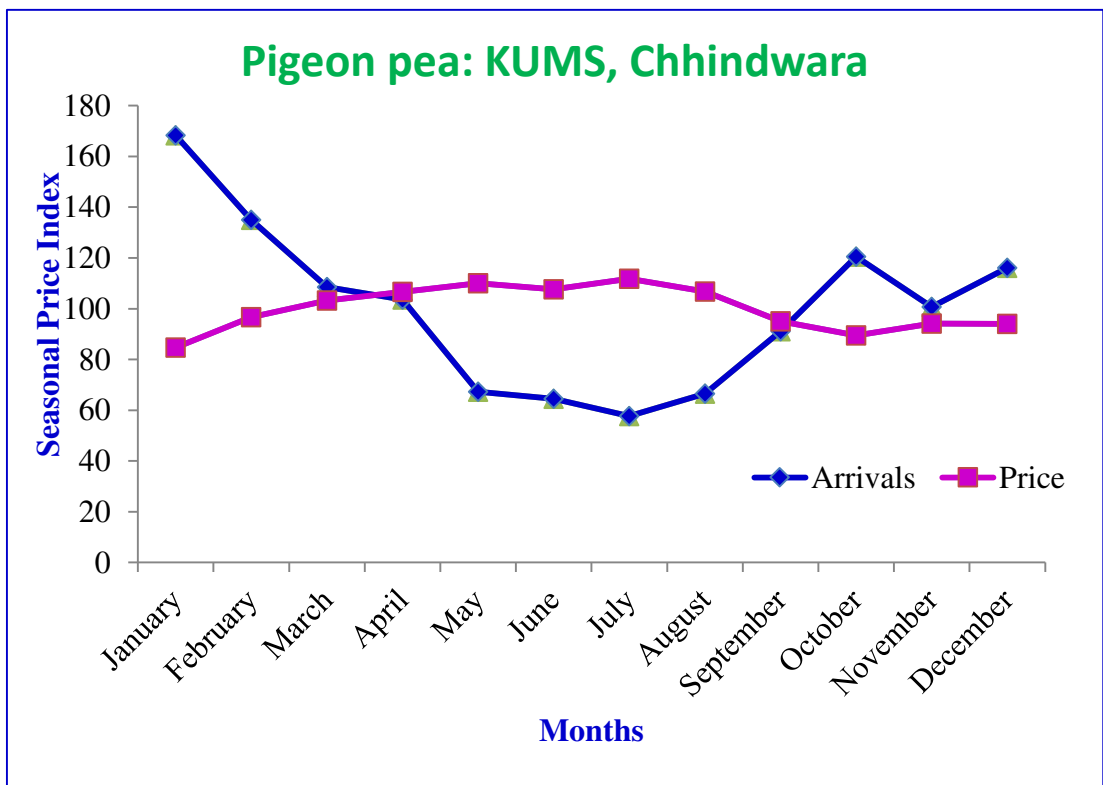
**Figure 4.59: Seasonal price index of monthly arrivals and prices of Lentil in KUMS, Gorakhpur (2008-2017)**



**Figure 4.60: Seasonal price index of monthly arrivals and prices of Black gram in KUMS, Ganjbasoda (2008-2017)**



**Figure 4.61: Seasonal price index of monthly arrivals and prices of Green gram in KUMS, Manawar (2008-2017)**



**Figure 4.62: Seasonal price index of monthly arrivals and prices of Pigeon pea in KUMS, Chhindwara (2008-2017)**

**APPENDIX-I**

**Area, Production and Productivity of Major pulse crops in Rajasthan (A: Lakh Hectare, P: Lakh tones and Y: Kg./ha.)**

Year \ Crops	Gram			Lentil			Black gram			Green gram			Pigeon pea		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
<b>1988-89</b>	12.82	9.67	754	0.12	0.10	836	1.40	0.68	487	2.66	1.18	444	0.31	0.26	850
<b>1989-90</b>	11.44	7.11	622	0.10	0.07	650	1.41	0.51	364	2.99	0.79	264	0.31	0.17	560
<b>1990-91</b>	16.53	10.11	612	0.14	0.12	861	1.53	0.55	361	3.74	1.30	349	0.37	0.25	674
<b>1991-92</b>	10.29	6.79	660	0.12	0.09	783	1.49	0.35	232	3.43	0.41	121	0.22	0.06	248
<b>1992-93</b>	14.49	7.94	548	0.17	0.15	860	1.58	0.63	398	3.81	1.47	387	0.20	0.10	512
<b>1993-94</b>	12.22	7.47	612	0.13	0.11	805	1.83	0.55	301	4.15	0.52	125	0.19	0.07	356
<b>1994-95</b>	15.87	13.71	864	0.12	0.11	876	1.47	0.38	256	4.19	1.28	306	0.23	0.12	524
<b>1995-96</b>	16.20	10.90	673	0.18	0.15	831	1.50	0.63	418	4.19	0.80	190	0.21	0.08	385
<b>1996-97</b>	15.19	10.71	705	0.31	0.32	1016	2.04	0.73	356	5.92	2.46	415	0.32	0.24	750
<b>1997-98</b>	22.14	19.25	869	0.33	0.40	1205	2.08	0.97	466	6.31	1.64	260	0.45	0.36	791
<b>1998-99</b>	28.16	20.74	737	0.50	0.53	1060	1.72	0.55	318	5.64	0.59	104	0.25	0.33	1321
<b>1999-00</b>	9.75	6.78	695	0.41	0.51	1231	1.20	0.34	283	4.15	0.41	99	0.26	0.16	609
<b>2000-01</b>	6.73	3.97	590	0.22	0.26	1189	1.13	0.33	288	4.58	0.79	173	0.25	0.10	378
<b>2001-02</b>	9.70	7.36	759	0.17	0.15	906	1.82	0.66	362	7.02	2.07	295	0.24	0.14	576
<b>2002-03</b>	4.50	3.41	757	0.06	0.06	966	2.59	0.47	182	5.15	0.33	63	0.17	0.04	236
<b>2003-04</b>	11.18	7.07	633	0.26	0.29	1103	2.40	1.25	523	8.29	5.14	620	0.20	0.16	815
<b>2004-05</b>	10.35	7.73	747	0.29	0.29	993	1.46	0.53	360	7.55	2.05	272	0.17	0.13	746
<b>2005-06</b>	10.82	4.79	443	0.19	0.17	908	1.39	0.35	253	8.00	1.30	163	0.20	0.13	647
<b>2006-07</b>	10.11	8.73	863	0.14	0.13	921	1.08	0.32	292	7.56	2.70	357	0.19	0.09	503
<b>2007-08</b>	12.31	5.74	466	0.15	0.11	709	1.45	0.77	529	10.60	4.17	393	0.18	0.16	876
<b>2008-09</b>	12.60	9.81	779	0.21	0.18	869	1.37	0.41	296	8.86	3.73	421	0.19	0.15	772
<b>2009-10</b>	8.84	5.35	605	0.27	0.24	896	1.16	0.31	263	9.23	0.44	48	0.18	0.07	381
<b>2010-11</b>	17.83	16.01	898	0.44	0.38	871	1.28	0.94	737	10.50	6.53	621	0.21	0.16	761
<b>2011-12</b>	14.34	10.61	740	0.32	0.36	1125	2.55	1.32	516	12.72	6.47	509	0.19	0.13	666
<b>2012-13</b>	12.53	12.77	1019	0.28	0.30	1100	2.18	1.25	575	7.90	2.34	296	0.17	0.15	879
<b>2013-14</b>	19.24	16.40	853	0.34	0.29	851	1.96	0.71	360	10.20	3.91	384	0.15	0.09	649
<b>2014-15</b>	12.56	9.11	725	0.43	0.39	919	2.02	1.12	556	8.94	4.61	515	0.13	0.10	736
<b>2015-16</b>	9.42	8.40	892	0.75	0.64	859	2.99	1.15	384	13.64	5.97	438	0.12	0.07	548
<b>2016-17</b>	15.48	14.09	911	0.76	0.76	1003	4.77	3.06	641	16.37	8.10	495	0.18	0.19	1088
<b>2017-18</b>	13.75	14.71	1070	0.82	0.78	1010	5.40	3.37	624	17.19	7.42	431	0.86	0.61	677

Source: Directorate of Economics and Statistics

A-Area, P-Production and Y-Productivity

**APPENDIX-II**

**Area, Production and Productivity of Major pulse crops in Madhya Pradesh (A: Lakh Hectare, P: Lakh tones and Y: Kg/ha.)**

Crops Year	Gram			Lentil			Black gram			Green gram			Pigeon pea		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
<b>1988-89</b>	22.37	15.66	700	3.18	1.51	476	6.25	1.92	307	1.63	0.55	337	4.50	6.00	1323
<b>1989-90</b>	21.57	14.27	661	3.15	1.45	461	6.10	1.71	280	1.58	0.42	269	4.40	4.20	943
<b>1990-91</b>	24.62	18.92	768	3.35	1.66	497	6.09	1.77	290	1.46	0.45	307	4.40	4.40	989
<b>1991-92</b>	21.38	17.15	802	3.48	1.61	462	5.53	1.44	261	1.29	0.34	261	4.10	3.20	774
<b>1992-93</b>	23.46	17.58	749	3.75	1.77	471	5.39	1.66	307	1.37	0.47	344	4.20	3.60	853
<b>1993-94</b>	23.42	19.54	834	3.98	1.91	479	5.43	1.69	312	1.30	0.45	344	4.30	4.10	968
<b>1994-95</b>	27.41	24.87	907	4.29	2.06	479	4.77	1.41	296	1.14	0.34	302	3.60	3.00	848
<b>1995-96</b>	26.60	19.88	747	4.10	2.29	458	4.73	1.62	343	1.12	0.37	329	3.80	3.00	792
<b>1996-97</b>	25.13	22.97	914	5.12	2.46	480	5.10	1.28	251	1.11	0.39	346	3.72	3.20	860
<b>1997-98</b>	25.83	24.41	945	4.79	2.06	430	5.36	1.87	349	1.09	0.37	342	3.61	2.57	711
<b>1998-99</b>	26.65	24.63	924	5.13	2.45	478	5.36	1.72	321	1.04	0.35	332	4.03	3.47	861
<b>1999-00</b>	25.72	25.35	986	5.35	2.79	522	5.47	1.27	315	1.00	0.31	309	3.17	2.71	854
<b>2000-01</b>	19.78	16.20	819	4.89	2.07	422	4.14	1.04	250	0.87	0.22	254	3.13	2.10	672
<b>2001-02</b>	25.54	24.08	943	5.00	2.40	481	4.43	1.60	362	0.83	0.29	342	3.05	2.51	821
<b>2002-03</b>	24.71	17.13	694	4.67	1.81	388	5.21	1.46	280	0.83	0.23	275	3.04	1.88	619
<b>2003-04</b>	27.91	25.85	926	4.79	2.40	502	6.13	2.25	367	0.89	0.31	355	3.15	2.56	811
<b>2004-05</b>	27.47	25.49	928	4.98	2.48	498	5.57	2.01	361	0.86	0.28	326	3.28	2.57	785
<b>2005-06</b>	25.61	23.71	926	5.64	2.88	510	4.43	1.57	353	0.76	0.25	325	3.23	2.38	739
<b>2006-07</b>	24.63	24.13	980	5.22	2.59	497	4.36	1.52	347	0.77	0.26	332	3.23	2.20	683
<b>2007-08</b>	24.39	17.35	711	4.68	2.06	440	4.66	1.64	351	0.77	0.26	339	3.25	2.18	670
<b>2008-09</b>	28.41	27.86	981	5.31	2.68	505	4.76	1.83	385	0.76	0.27	353	3.21	2.58	804
<b>2009-10</b>	30.86	33.04	1071	5.41	2.84	525	4.99	1.90	380	0.82	0.28	339	3.62	3.08	851
<b>2010-11</b>	31.12	26.87	863	5.91	1.77	300	5.85	1.28	390	0.96	0.34	358	4.88	1.65	337
<b>2011-12</b>	30.44	32.90	1081	6.21	2.30	371	5.51	1.49	270	0.85	0.21	252	5.35	3.34	625
<b>2012-13</b>	31.29	38.12	1219	5.71	3.33	584	6.51	3.90	600	0.88	0.41	466	5.30	3.50	662
<b>2013-14</b>	31.60	32.99	1044	5.30	3.38	638	6.02	2.26	376	3.16	1.46	462	4.60	3.30	716
<b>2014-15</b>	28.53	29.64	1039	6.14	4.16	678	8.82	4.40	499	2.61	1.24	477	5.20	5.10	981
<b>2015-16</b>	30.17	33.64	1115	5.46	3.92	719	9.35	5.17	553	2.95	1.31	445	5.80	6.20	1079
<b>2016-17</b>	32.22	35.44	1100	5.29	4.47	846	12.03	8.17	679	4.87	2.96	607	6.90	7.80	1133
<b>2017-18</b>	35.90	45.95	1280	5.96	6.79	1133	18.04	13.20	731	2.97	2.20	740	6.47	8.39	1292

Source: Directorate of Economics and Statistics

A-Area, P-Production and Y-Productivity

**APPENDIX-III**

**Area, Production and Productivity of Major pulse crops in Uttar Pradesh (A: Lakh Hectare, P: Lakh tones and Y: Kg./ha.)**

Crops Year	Gram			Lentil			Black gram			Green gram			Pigeon pea		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
<b>1988-89</b>	13.25	11.67	881	4.61	3.52	764	2.05	0.70	344	0.18	0.04	230	4.9	6.6	1355
<b>1989-90</b>	13.04	9.69	743	4.90	3.47	708	2.11	0.62	295	0.19	0.05	263	5.00	6.00	1193
<b>1990-91</b>	12.75	11.22	879	5.40	4.31	796	2.27	0.76	335	0.24	0.07	283	4.70	5.80	1234
<b>1991-92</b>	11.05	9.43	853	5.42	4.15	767	2.09	0.84	400	0.24	0.06	245	5.20	5.60	1073
<b>1992-93</b>	10.65	9.51	893	5.43	3.95	726	2.38	1.12	470	0.27	0.07	264	5.30	5.50	1034
<b>1993-94</b>	10.13	9.31	919	4.94	3.67	742	2.38	0.85	357	0.24	0.06	260	5.30	5.50	1034
<b>1994-95</b>	10.37	9.48	898	4.60	3.58	778	1.99	0.78	390	0.21	0.05	238	5.20	5.10	991
<b>1995-96</b>	10.06	6.98	942	4.87	3.17	650	2.21	1.01	457	0.24	0.08	333	5.00	5.00	1014
<b>1996-97</b>	9.17	8.52	930	4.87	4.49	811	2.61	1.09	417	0.29	0.09	298	4.96	5.65	1139
<b>1997-98</b>	8.82	7.47	847	5.06	3.65	723	2.92	1.22	418	0.28	0.08	292	4.66	4.81	1032
<b>1998-99</b>	8.87	7.73	872	5.46	3.95	725	2.88	0.77	268	0.26	0.06	217	4.27	4.97	1164
<b>1999-00</b>	8.22	7.79	948	5.86	4.85	828	2.72	1.13	415	0.27	0.08	296	4.15	5.44	1312
<b>2000-01</b>	8.33	7.03	844	6.52	4.08	626	3.22	1.34	416	0.28	0.09	303	4.07	5.10	1254
<b>2001-02</b>	8.41	8.17	971	6.25	5.00	800	3.63	1.48	408	0.28	0.08	274	3.94	4.56	1157
<b>2002-03</b>	8.73	7.79	893	5.84	4.50	771	4.02	1.60	399	0.22	0.06	284	3.58	3.42	955
<b>2003-04</b>	7.61	7.87	1035	5.57	5.05	907	4.98	1.20	242	0.26	0.08	315	3.69	4.06	1101
<b>2004-05</b>	7.39	6.72	910	6.13	5.01	818	4.76	1.77	372	0.32	0.09	276	3.87	3.80	982
<b>2005-06</b>	7.39	6.61	893	6.08	4.35	715	4.92	2.11	429	0.29	0.08	267	3.83	3.78	987
<b>2006-07</b>	6.75	5.01	742	6.16	4.34	705	4.74	2.66	561	0.42	0.17	405	4.06	3.04	749
<b>2007-08</b>	5.05	3.76	745	5.07	3.68	726	3.42	1.50	439	0.31	0.06	194	3.68	3.28	891
<b>2008-09</b>	5.54	5.62	1014	5.21	4.60	883	3.63	1.95	537	0.31	0.11	355	3.15	2.88	914
<b>2009-10</b>	6.18	5.09	824	5.92	4.76	803	5.53	2.24	405	0.72	0.32	444	3.05	2.02	662
<b>2010-11</b>	5.70	5.30	930	5.86	4.11	701	5.56	3.72	669	0.89	0.62	697	3.44	3.09	898
<b>2011-12</b>	5.77	6.84	1185	5.73	5.05	881	5.07	3.39	669	0.38	0.16	421	3.20	3.34	1044
<b>2012-13</b>	6.04	6.76	1119	4.95	4.41	891	5.72	3.80	664	0.78	0.51	654	3.10	3.30	1045
<b>2013-14</b>	5.77	4.75	824	4.49	3.10	690	5.42	2.48	458	0.79	0.39	494	3.00	2.70	900
<b>2014-15</b>	5.58	3.68	659	4.38	2.35	537	5.63	3.02	536	0.88	0.46	523	2.90	1.70	606
<b>2015-16</b>	2.68	1.64	612	3.35	2.38	710	6.17	2.44	395	1.11	0.51	459	2.70	1.80	691
<b>2016-17</b>	5.62	6.26	1114	4.89	3.72	761	6.44	3.53	548	0.92	0.52	565	3.40	3.60	1074
<b>2017-18</b>	6.11	6.84	1195	5.10	4.00	806	6.14	3.15	513	0.99	0.65	656	2.82	3.03	1074

Source: Directorate of Economics and Statistics

A-Area, P-Production and Y-Productivity

**APPENDIX-IV**

**Area, Production and Productivity of Major pulse crops in Maharashtra (A: Lakh Hectare, P: Lakh tones and Y: Kg./ha.)**

Crops Year	Gram			Lentil			Black gram			Green gram			Pigeon pea		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1988-89	6.67	4.08	611	0.10	0.05	505	4.85	2.03	418	7.86	3.27	416	9.00	6.00	666
1989-90	6.27	3.35	533	0.09	0.04	440	3.73	1.68	451	7.41	2.97	401	9.50	7.10	747
1990-91	6.73	3.58	532	0.08	0.03	405	3.87	1.92	497	7.38	3.07	416	10.10	4.20	418
1991-92	4.34	2.06	475	0.04	0.01	359	4.07	1.07	264	7.38	1.72	233	10.20	3.60	357
1992-93	5.91	3.02	510	0.10	0.03	255	4.69	3.09	659	7.51	4.56	607	10.20	5.90	576
1993-94	6.81	4.93	725	0.12	0.05	425	4.92	3.17	643	7.45	4.37	586	10.30	7.50	730
1994-95	7.63	4.69	614	0.14	0.06	390	5.05	2.31	458	7.55	2.86	379	10.60	5.30	498
1995-96	7.17	3.76	524	0.10	0.05	471	4.88	2.24	458	6.45	2.53	392	10.50	6.30	596
1996-97	7.50	4.98	665	0.10	0.05	485	5.24	2.70	515	6.41	3.39	528	10.47	7.17	684
1997-98	7.15	2.91	407	0.07	0.03	429	5.25	2.10	401	6.13	1.91	312	10.06	3.55	353
1998-99	9.04	5.62	621	0.07	0.03	419	5.32	3.38	636	6.49	3.76	579	10.07	8.09	804
1999-00	9.32	6.00	644	0.09	0.04	471	5.49	2.70	491	6.57	3.06	466	10.41	8.68	834
2000-01	6.76	3.51	519	0.06	0.02	333	5.74	2.05	357	7.14	2.44	341	10.96	6.60	602
2001-02	7.56	4.50	595	0.08	0.04	500	5.88	2.56	435	7.11	2.91	409	10.23	7.73	756
2002-03	7.96	4.49	564	0.06	0.02	333	6.34	3.60	568	7.62	3.76	493	10.60	7.77	733
2003-04	7.95	4.21	530	0.08	0.03	375	6.01	3.59	597	7	3.91	558	10.56	6.95	658
2004-05	8.30	4.66	561	0.06	0.01	255	5.30	2.16	408	6.56	2.28	348	10.74	6.58	613
2005-06	10.20	7.05	691	0.09	0.04	414	4.68	1.99	425	5.34	1.89	354	11.00	7.92	720
2006-07	13.08	9.24	706	0.09	0.04	411	4.90	2.00	408	5.73	2.36	412	3.23	2.20	683
2007-08	13.53	11.16	825	0.10	0.05	500	5.64	3.20	567	6.61	3.67	555	3.25	2.18	670
2008-09	11.43	7.74	677	0.08	0.03	375	3.24	1.00	309	4.27	1.06	248	3.21	2.58	804
2009-10	12.91	11.14	863	0.09	0.03	364	3.54	1.17	331	4.28	1.42	332	3.62	3.08	851
2010-11	14.38	13.00	904	0.04	0.02	500	4.82	3.29	683	5.54	3.72	671	4.88	1.65	337
2011-12	10.51	8.15	775	0.03	0.01	452	3.64	2.49	684	4.33	2.54	587	5.35	3.34	625
2012-13	11.20	8.54	763	0.04	0.01	400	3.60	2.13	600	4.35	2.12	489	5.30	3.50	662
2013-14	18.20	16.22	891	0.05	0.02	360	3.34	2.06	376	4.31	2.08	483	4.60	3.30	716
2014-15	14.27	10.88	762	0.03	0.01	355	2.77	0.92	499	3.15	0.84	267	5.20	5.10	981
2015-16	14.42	7.77	539	0.05	0.04	436	2.86	0.61	553	3.66	0.69	189	5.80	6.20	1079
2016-17	19.29	17.19	891	0.06	0.05	480	3.38	1.83	679	4.44	2.6	585	6.90	7.80	1133
2017-18	20.00	17.61	880	0.08	0.06	490	3.51	1.21	731	4.53	1.63	360	6.47	8.39	1292

Source: Directorate of Economics and Statistics

A-Area, P-Production and Y-Productivity

**APPENDIX-V**

**Area, Production and Productivity of Major pulse crops in Karnataka (A: Lakh Hectare, P: Lakh tones and Y: Kg./ha.)**

Crops Year	Gram			Black gram			Green gram			Pigeon pea		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1988-89	1.88	0.62	329	0.69	0.22	323	2.25	0.88	391	5.00	1.50	298
1989-90	2.24	0.75	333	0.72	0.21	290	1.89	0.63	331	4.80	1.90	387
1990-91	2.30	0.69	298	0.81	0.20	247	2.78	1.21	434	4.60	1.80	379
1991-92	1.96	0.77	391	1.00	0.42	420	3.40	1.99	585	5.00	1.70	345
1992-93	2.10	0.74	354	1.04	0.58	555	2.36	0.92	389	4.50	0.90	192
1993-94	2.90	1.32	455	1.00	0.64	641	1.53	0.44	287	3.60	1.60	430
1994-95	4.41	2.22	502	1.05	0.27	261	1.88	0.46	243	3.00	1.20	395
1995-96	2.93	1.42	483	1.14	0.86	758	1.67	0.61	363	4.20	2.00	476
1996-97	3.48	1.94	557	1.35	0.30	219	3.03	0.56	184	4.50	2.30	514
1997-98	3.37	1.15	341	1.39	0.31	220	2.38	0.32	136	4.22	0.99	234
1998-99	3.55	2.03	570	1.36	0.46	338	3.12	0.61	196	4.75	2.22	466
1999-00	3.19	1.75	549	1.19	0.39	328	3.76	1.30	346	5.08	2.90	570
2000-01	3.70	2.39	648	1.34	0.52	387	4.35	1.81	415	5.83	2.64	452
2001-02	4.80	2.82	587	1.51	0.56	369	2.51	0.65	260	4.82	1.47	306
2002-03	4.80	2.52	525	1.49	0.21	143	4.02	0.26	66	5.14	2.41	469
2003-04	5.10	1.71	336	1.29	0.33	252	2.64	0.40	149	5.32	2.00	375
2004-05	4.18	2.24	536	1.22	0.14	115	5.18	0.82	158	5.62	2.90	516
2005-06	4.18	2.29	548	1.01	0.19	188	3.93	0.87	221	6.01	4.37	727
2006-07	6.51	3.08	473	1.34	0.18	134	4.40	0.52	118	5.96	2.80	470
2007-08	6.05	3.67	607	1.52	0.62	408	5.21	1.08	207	6.81	4.85	712
2008-09	7.26	4.01	552	1.01	0.24	238	2.66	0.35	132	5.97	3.15	528
2009-10	9.72	5.74	591	1.09	0.10	92	3.70	0.44	119	6.04	2.82	467
2010-11	9.59	6.31	658	1.18	0.41	347	3.91	1.08	276	8.91	5.29	594
2011-12	8.03	4.68	583	0.84	0.31	369	2.84	0.70	246	7.67	3.54	462
2012-13	6.04	6.76	643	1.10	0.53	482	1.75	0.52	297	6.60	3.66	555
2013-14	5.77	4.75	757	1.02	0.50	490	3.20	0.81	253	8.24	5.88	713
2014-15	5.58	3.68	718	0.70	0.21	300	2.63	0.53	202	7.28	4.74	651
2015-16	2.68	1.64	466	0.91	0.25	275	3.48	0.44	126	6.57	2.42	368
2016-17	5.62	5.92	590	0.88	0.43	489	4.20	1.16	275	12.14	9.09	749
2017-18	13.75	8.25	600	1.38	0.47	340	3.97	0.96	240	8.85	7.29	823

Source: Directorate of Economics and Statistics  
A-Area, P-Production and Y-Productivity

**APPENDIX-VI**

**Area of Competitive crops of Major pulse crops in Selected States of India (Area: Lakh Hectare)**

State Year	Rajasthan		Madhya Pradesh		Uttar Pradesh		Maharashtra		Karnataka	
	W	B	W	S	W	P	W	C	W	P
1988-89	17.7	57.08	36.67	14.76	87.02	53.78	8.79	26.28	2.38	10.25
1989-90	16.5	49.28	32.84	18.78	86.38	54.26	8.42	26.36	2.48	9.79
1990-91	18.14	48.55	38.34	21.49	85.68	56.15	8.73	27.30	1.98	9.77
1991-92	17.79	45.97	35.47	26.49	86.31	54.10	6.28	27.24	1.99	10.09
1992-93	22.51	50.03	36.72	30.54	89.08	54.74	6.80	24.80	2.24	10.31
1993-94	20.13	43.64	41.48	34.15	90.30	53.64	7.53	24.79	2.37	10.50
1994-95	23.22	49.78	41.93	32.25	89.95	55.72	7.67	27.60	2.43	10.40
1995-96	21.96	42.72	40.20	38.49	89.24	55.61	7.02	30.65	2.19	10.09
1996-97	24.74	47.10	43.27	41.66	90.14	55.45	7.99	30.85	2.48	10.51
1997-98	26.8	47.02	45.90	44.70	91.53	56.57	7.47	31.39	2.51	10.32
1998-99	27.66	41.84	46.62	45.89	93.18	58.75	10.16	31.99	2.69	10.79
1999-00	26.5	39.45	46.62	44.39	94.00	60.80	10.49	32.54	2.61	10.96
2000-01	23.1	46.37	33.11	44.76	92.39	59.04	7.54	30.77	2.66	11.21
2001-02	22.87	51.30	37.04	44.50	92.56	60.68	7.76	31.05	2.26	10.88
2002-03	18.01	32.15	33.82	41.91	90.94	52.09	7.60	28.00	2.47	10.31
2003-04	21.03	58.58	40.91	42.12	91.50	59.49	6.65	27.62	2.32	9.44
2004-05	20.1	45.65	41.36	44.85	90.00	53.37	7.56	28.40	2.42	10.56
2005-06	21.24	49.62	36.93	42.55	91.64	55.72	9.33	28.75	2.53	10.76
2006-07	25.65	48.79	39.93	47.57	91.98	59.03	12.31	31.07	2.69	10.66
2007-08	25.92	50.77	37.42	50.24	91.15	56.90	12.53	31.95	2.76	10.51
2008-09	22.95	51.75	37.85	51.24	95.13	60.12	10.22	31.46	2.69	11.30
2009-10	23.94	51.69	42.76	53.50	96.67	51.73	10.81	34.95	2.83	11.02
2010-11	24.79	54.89	43.41	55.60	96.37	56.57	13.07	39.42	2.55	11.30
2011-12	29.35	50.20	48.89	56.69	97.31	59.23	8.43	41.25	2.25	11.18
2012-13	30.63	39.89	53.00	60.32	97.34	58.37	7.73	41.46	2.25	10.48
2013-14	28.1	44.35	53.80	63.09	98.39	59.55	10.97	41.92	2.09	10.35
2014-15	33.18	40.77	60.02	55.78	98.46	58.42	10.67	41.90	1.98	10.00
2015-16	31.09	40.45	59.11	59.06	96.45	58.37	9.11	42.07	1.74	9.77
2016-17	28.3	41.50	60.28	54.01	96.55	59.66	12.72	38.00	1.68	9.42
2017-18	28.1	42.36	53.16	50.10	97.53	57.88	10.24	43.51	1.93	7.37

Source: Directorate of Economics and Statistics

W-Wheat, B-Bajara, S-Soybean, P-Paddy and C-Cotton

**APPENDIX-VII**  
**Seasonal Rainfall in Selected States of India (In 10<sup>th</sup> of MM)**

State Year	Rajasthan		Madhya Pradesh		Uttar Pradesh		Maharashtra		Karnataka	
	RR	KR	RR	KR	RR	KR	RR	KR	RR	KR
1988-89	331	3310.8	636	23234.4	1128	22809.6	559	24561.6	1395	52932
1989-90	296	3187.2	819	18769.2	1418	19482	871	21238.1	967	46174.8
1990-91	644	5774.4	979	29960.4	1640	21468	369	22590	1189	41428.8
1991-92	348	1593.6	767	19766.4	1241	17035.2	467	16394.4	1817	50751.6
1992-93	408	5014.8	93	21760.8	564	17563.2	415	16136.4	3319	47970
1993-94	304	3542.4	696	25165.2	908	16794	1382	17952	2643	45927.6
1994-95	725	4000.8	987	32905.2	1219	18828	1015	14972.4	2153	54073.2
1995-96	833	4158	2100	22018.8	1292	17906.4	1347	14145.6	1544	47365.2
1996-97	268	4316.4	1243	24862.8	1790	20997.6	487	19221.6	1660	47733.6
1997-98	749	4610.4	10496	24078	1931	19868.4	3094	14396.4	4028	50034
1998-99	548	4242	1572	23554.8	1244	24538.8	749	23853.6	2542	52575.6
1999-00	270	2312.4	859	29730	577	22053.6	204	16376.4	1227	49946.4
2000-01	118	2650.8	101	18130.8	753	20714.4	353	16881.6	1454	44112
2001-02	1431	3223.2	714	23257.2	437	20061.6	350	16340.4	2542	40286.4
2002-03	408	909.6	950	18416.4	1381	13906.8	663	14468.4	1015	37591.2
2003-04	638	3439.2	1281	25971.6	1754	24262.8	472	13939.2	1318	46424.4
2004-05	140	1939.2	750	19821.6	890	14851.2	301	15847.2	1798	36292.8
2005-06	449	2294.4	1072	23436	1105	17811.6	604	21435.6	3178	47000.4
2006-07	379	4477.2	1563	24262.8	995	16414.8	1002	21879.6	2376	43292.4
2007-08	1196	2836.8	799	19003.2	2143	15897.6	1463	18742.8	5593	53096.4
2008-09	351	3103.2	461	21445.2	311	33380.4	874	17305.2	5121	38116.8
2009-10	325	2080.8	2250	19740	501	15608.4	886	15037.2	2980	50444.4
2010-11	1372	4743.6	861	20916	650	19896	1555	19813.2	6973	57534
2011-12	263	4016.4	268	27270	452	19707.6	390	15819.6	3167	50011.2
2012-13	242	3788.4	799	24978	1128	17565.6	300	11206.8	3615	40923.6
2013-14	957	5325.6	1465	35476.8	3215	21694.8	402	20875.2	1808	47722.8
2014-15	847	3222	2360	19653.6	2516	16168.8	1733	10651.4	1749	47799.6
2015-16	1579	4323.6	3041	21578.4	2662	11383.2	1385	10303.2	4628	34173.6
2016-17	105	4009.2	522	29389.2	327	17769.6	286	19993.2	818	33410.4
2017-18	346	9688	221	17714.4	614	12699.9	207	17075	649	13288.4

Source: Directorate of Economics and Statistics

RR: Rabi season rainfall and KR: Kharif season rainfall

**APPENDIX-VIII**

**Monthly arrivals and wholesale price of Major Pulse Crops in Major KUMS of Rajasthan (January 2008 to December 2017)**

<b>KUMS (Crops)</b>	<b>Bikaner (Gram)</b>		<b>Bundi (Lentil)</b>		<b>Bundi (Black gram)</b>		<b>Kekari (Green gram)</b>		<b>Pratapguarh(Pigeon pea)</b>	
<b>Month</b>	<b>A</b>	<b>P</b>	<b>A</b>	<b>P</b>	<b>A</b>	<b>P</b>	<b>A</b>	<b>P</b>	<b>A</b>	<b>P</b>
<b>January 08</b>	2300	5100	1940	2750	8090	2520	5660	2820	1230	3420
<b>February 08</b>	3050	5120	2120	2710	5020	2560	2210	2890	2150	2250
<b>March, 08</b>	12050	4250	6150	2100	3220	2630	2120	3220	1820	2280
<b>April, 08</b>	33500	3000	4607	2150	3027	2725	2096	3300	930	2652
<b>May, 08</b>	22650	3200	3766	2300	2974	2750	2066	3420	928	2900
<b>Jun, 08</b>	14500	3350	3113	2500	2571	2850	1793	3550	881	4200
<b>July, 08</b>	13870	3739	4129	2650	1299	2925	1146	4175	373	5500
<b>August, 08</b>	9482	3888	3414	2700	1322	2600	1593	3450	602	4900
<b>September, 08</b>	8529	4060	4091	3000	4295	2700	2379	3200	600	4400
<b>October, 08</b>	4218	4872	1889	2650	3637	2625	2579	2900	650	4350
<b>November, 08</b>	1457	5335	2501	3300	18278	2250	13992	2750	625	3850
<b>December, 08</b>	2519	5011	1934	2800	14361	2500	6475	2780	575	3500
<b>January 09</b>	10080	4800	1320	3000	5333	2575	6848	2775	1651	2800
<b>February 09</b>	13085	4850	1224	2800	4926	2600	4905	2800	2729	2700
<b>March, 09</b>	14890	4900	13549	1800	3296	2750	3035	3100	2258	2900
<b>April, 09</b>	65294	3892	10346	3200	2974	2800	2479	3500	2110	3200
<b>May, 09</b>	46999	4309	11210	3350	2489	2820	1774	3530	1275	3300
<b>Jun, 09</b>	22510	3908	7774	3550	2261	3000	1340	3950	1178	5620
<b>July, 09</b>	21923	4669	8281	3800	2137	3800	1161	4550	277	5700
<b>August, 09</b>	11789	4542	3716	3800	2305	3500	1443	4200	906	4720
<b>September, 09</b>	25772	4284	1870	3850	1525	3500	4811	4150	813	4500
<b>October, 09</b>	9038	5263	1018	3900	8831	2300	2675	3700	751	4550
<b>November, 09</b>	6660	5568	1485	3500	12528	2050	9189	2300	449	4500
<b>December, 09</b>	9838	5443	1964	3250	9664	2400	8345	2600	333	4500
<b>January 10</b>	4936	3062	641	3100	7362	3000	9782	2980	1093	3540
<b>February 10</b>	3298	3495	1613	2600	7234	3020	8520	3000	3910	2900
<b>March, 10</b>	6835	3853	11589	2200	4279	3040	8146	3160	2615	2950
<b>April, 10</b>	204756	3283	8815	2900	2328	3500	3215	3220	1625	3700
<b>May, 10</b>	34948	3640	8290	2800	1624	3700	2246	3300	1246	3800
<b>Jun, 10</b>	10545	4198	7775	2700	1342	4720	1971	3470	1236	3900

Source:Krishi Upaj Mandi Samities

(A: Arrivals in qtls and P: Wholesale prices in Rs.)

KUMS (Crops)	Bikaner (Gram)		Bundi (Lentil)		Bundi (Black gram)		Kekari (Green gram)		Pratapguarh(Pigeon pea)	
	A	P	A	P	A	P	A	P	A	P
July, 10	13047	4465	5347	2750	1043	5500	1202	4400	534	4000
August, 10	12251	4583	5693	2250	1591	4200	1453	4000	1136	4200
September, 10	12026	4647	4117	2500	1625	3900	1811	3950	1100	4250
October, 10	13839	5066	527	3900	3729	3600	4596	3120	939	4300
November, 10	12180	5355	1386	3000	16503	2550	19855	2600	840	4800
December, 10	12588	5016	1741	2450	9921	2850	17896	2950	760	3600
January 11	3476	3928	1525	2250	9009	3800	10373	4200	1735	4400
February 11	4355	3700	1330	2300	4533	4200	3171	4500	2757	3300
March, 11	32230	3833	11653	2100	3132	3900	2004	3800	2437	3300
April, 11	220292	2445	4646	2701	2097	3905	1341	3700	2446	2320
May, 11	138972	3010	4369	2505	1748	3910	1880	4000	2250	3500
Jun, 11	100007	3181	5833	2424	1334	3955	5008	4000	1271	4600
July, 11	31814	3234	5760	2402	1034	4000	1016	4800	520	5700
August, 11	20532	3300	5630	2418	1274	3500	1112	3500	929	4720
September, 11	25897	3351	4892	2664	1954	3100	13950	2800	909	4150
October, 11	3062	3586	930	3440	5791	2400	12724	2100	850	4200
November, 11	3161	4401	1964	3300	25955	2200	18897	1800	756	4500
December, 11	3560	3650	3611	2516	20739	2270	16999	1850	658	4900
January 12	11662	2756	4127	2678	9461	2900	12401	2950	1312	3200
February 12	11403	2570	3428	2488	7104	2950	9712	3150	3156	2800
March, 12	11413	2409	13290	2200	5161	3000	3789	3200	2223	3700
April, 12	82148	2360	9149	3163	5116	3220	2650	3250	1600	3900
May, 12	70350	3107	7097	3634	3951	3250	2344	4000	1250	4550
Jun, 12	19225	3899	6039	3480	1747	3400	2302	4200	300	5400
July, 12	53619	4168	5208	3602	1326	3600	1276	4800	178	6500
August, 12	30832	4150	3489	3689	1874	3500	2112	3500	1189	5900
September, 12	18253	4411	3027	3711	1954	3400	2350	2800	958	3700
October, 12	9442	4649	1820	3984	5791	3050	2724	2650	950	3600
November, 12	7639	5191	2537	3477	14331	2500	17935	2500	750	3500
December, 12	9689	4598	2711	3762	12218	2820	15894	2900	900	3400

Source:Krishi Upaj Mandi Samities

(A: Arrivals in qtls and P: Wholesale prices in Rs.)

KUMS(Crops)	Bikaner (Gram)		Bundi (Lentil)		Bundi (Black gram)		Kekari (Green gram)		Pratapguarh(Pigeon pea)	
	A	P	A	P	A	P	A	P	A	P
January 13	11802	4863	1480	3700	11040	3250	5020	2930	1289	3500
Februarys 13	21512	4238	1613	2990	3665	3300	4415	3100	4178	2900
March, 13	31187	4075	12695	2120	3362	3350	3944	3200	3130	2750
April, 13	94116	3957	11859	2420	2964	3400	3126	3350	2152	2950
May, 13	39904	4376	10064	2989	2918	3500	2448	3400	2200	3350
Jun, 13	28432	4456	7885	3261	2226	3650	2865	3900	1240	5500
July, 13	19796	4296	7752	4024	1838	3800	2111	4600	200	6400
August, 13	13223	4021	3645	4193	1894	3500	2240	4500	1195	4500
September, 13	11781	4100	2048	4314	2231	3350	2739	4400	2105	4300
October, 13	9002	4579	1257	5084	4700	3040	5346	4350	2150	3350
November, 13	8423	4962	1501	4900	16457	2600	8685	2200	2190	3500
December, 13	11036	4903	3098	4448	11679	2900	6267	2600	2171	4000
January 14	8193	3605	1920	3913	9738	2850	6404	3000	1707	2800
February 14	10956	4033	2006	3597	6216	2990	5022	3100	4178	2500
March, 14	13402	4374	14008	3543	2447	3100	5286	3300	3189	2800
April, 14	95128	5038	10624	4563	2272	3200	4620	3450	1250	3600
May, 14	22583	3728	9686	4522	2166	3250	3905	3500	1200	3500
Jun, 14	18783	3980	6272	4772	1800	3500	2961	3500	950	5400
July, 14	33699	4792	5586	4118	1132	4900	1377	6350	718	6500
August, 14	14471	3933	4182	4201	2878	4250	3021	6000	978	4000
September, 14	12992	3715	3249	4481	3683	4100	2835	5000	1159	4100
October, 14	13378	4352	1249	5525	5661	3800	10019	4050	1190	4300
November, 14	6305	5291	1321	5326	37740	2340	19008	2850	1206	4400
December, 14	7352	4004	2098	5035	9771	2800	7650	2920	1306	4500
January 15	8615	3671	1996	4351	13402	2420	9016	3100	1526	3100
February 15	9813	3565	2321	4330	5879	2850	5366	3200	4125	3000
March, 15	27434	3497	11721	4415	4054	2950	4780	3210	3279	3800
April, 15	81901	2625	10583	5253	3509	3020	4630	3220	2156	3900
May, 15	75503	2983	9216	5909	3019	3200	3093	3600	1580	4100
Jun, 15	34302	3130	7412	5706	2306	3550	3378	3750	1405	6500

Source:Krishi Upaj Mandi Samities  
(A: Arrivals and P: Wholesale prices)

<b>KUMS(Crops)</b>	<b>Bikaner (Gram)</b>		<b>Bundi (Lentil)</b>		<b>Bundi (Black gram)</b>		<b>Kekari (Green gram)</b>		<b>Pratapguarh(Pigeon pea)</b>	
<b>Month</b>	<b>A</b>	<b>P</b>	<b>A</b>	<b>P</b>	<b>A</b>	<b>P</b>	<b>A</b>	<b>P</b>	<b>A</b>	<b>P</b>
<b>July, 15</b>	24593	3561	6442	5400	1258	3900	2115	6200	360	6900
<b>August, 15</b>	22487	3827	3035	5420	1692	3450	5019	6150	1300	6300
<b>September, 15</b>	18995	3831	2835	5551	1902	3320	3709	4150	1250	6200
<b>October, 15</b>	10062	4562	1443	6001	7399	2500	18266	3800	1198	6150
<b>November, 15</b>	6950	4775	1840	5900	26015	2240	24523	2500	985	6000
<b>December, 15</b>	8557	4354	2550	5771	15134	2400	18836	2950	880	5900
<b>January 16</b>	9108	4666	1784	4633	6999	2930	7458	2970	935	3900
<b>February 16</b>	9779	3977	1976	4815	5554	3000	5025	3000	2240	3500
<b>March, 16</b>	46616	3261	12175	4433	4464	3120	4179	3100	1256	4400
<b>April, 16</b>	296108	3041	11258	4560	4225	3200	3745	3200	1156	4450
<b>May, 16</b>	181872	3466	9537	4570	3106	3200	3002	3300	120	5200
<b>Jun, 16</b>	87722	3764	8941	5235	2161	3400	2896	5300	130	5300
<b>July, 16</b>	17533	4105	6125	5564	1783	4120	2341	5900	125	6500
<b>August, 16</b>	12315	4139	4500	5595	1988	3500	2896	4600	160	6400
<b>September, 16</b>	9136	4235	3165	5650	5419	3400	2726	4200	150	6350
<b>October, 16</b>	8399	4840	892	6800	6858	3150	8753	3950	140	5450
<b>November, 16</b>	7054	5082	915	6410	23719	2620	16720	2200	165	4300
<b>December, 16</b>	8558	4597	967	5145	9346	2700	13229	2950	156	4000
<b>January 17</b>	12950	5026	1238	5400	8371	2450	9204	3000	2546	4000
<b>February 17</b>	12127	5117	4171	3421	6687	2900	8128	3400	5350	2800
<b>March, 17</b>	53417	3136	11283	3410	2938	3200	4474	4420	3450	3600
<b>April, 17</b>	216571	2984	9512	4773	1955	3200	3700	4530	2456	4500
<b>May, 17</b>	117689	5525	8603	4198	1779	3350	2800	4700	1402	4250
<b>Jun, 17</b>	33757	4954	6294	3594	1654	3400	1900	4900	1400	5200
<b>July, 17</b>	20223	4797	3728	3387	1098	4300	1800	5300	1147	5800
<b>August, 17</b>	21245	4830	3391	3822	1681	3950	7500	4800	1235	3500
<b>September, 17</b>	18471	4901	1387	3580	1818	3250	6400	4300	1340	3600
<b>October, 17</b>	16713	4976	1087	5520	8832	2900	6150	3900	1350	3650
<b>November, 17</b>	11157	5715	2329	5440	18867	2250	16200	2200	1365	3600
<b>December, 17</b>	12654	5006	4677	3365	12975	2350	16000	2900	1371	3700

Source:Krishi Upaj Mandi Samities  
(A: Arrivals and P: Wholesale prices)

**APPENDIX-IX**

**Monthly arrivals and wholesale price of Major Pulse Crops in Major KUMS of Madhya Pradesh (January 2008 to December 2017)**

KUMS(Crops)	Dewas (Gram)		Gorakhpur (Lentil)		Gajbasoda (Black gram)		Manawar (Green gram)		Chhindwara (Pigeon pea)	
	A	P	A	P	A	P	A	P	A	P
January 08	8506	2800	3000	2850	2606	2200	3240	2450	1820	2250
February 08	8030	2700	3500	2700	2203	2250	3160	2360	1740	2310
March, 08	9800	2550	6500	2200	2210	2300	3120	2345	1720	2320
April, 08	52400	2250	8607	2100	3020	2200	2729	2300	1791	2400
May, 08	51385	2300	7766	2600	1109	2258	2498	2230	1629	2750
Jun, 08	10072	2350	5113	2800	1050	1895	2380	3250	1620	2900
July, 08	11599	2450	5109	3250	1090	2500	2034	3575	215	3600
August, 08	11256	2800	4514	2700	1500	2182	2515	2900	245	3200
September, 08	8737	2800	3791	3000	2801	2300	1880	2800	332	3100
October, 08	6569	3500	2889	3200	3100	2247	2858	2130	404	3000
November, 08	6860	3300	2629	3390	3936	2150	5399	2500	776	3100
December, 08	7054	2950	2814	2900	3829	2196	4079	2500	1148	2800
January 09	11443	2450	2920	2800	3206	2436	3101	2500	1880	2100
February 09	53967	2000	2924	2805	3080	2148	2680	2800	7154	3000
March, 09	29700	2220	5549	2800	3150	2148	2670	2700	3978	2900
April, 09	21976	1920	8346	2750	2678	3182	2442	4900	1877	3500
May, 09	18382	2330	7210	3300	2760	3098	2218	4600	741	3600
Jun, 09	8278	2450	5774	3500	2690	3198	2130	4650	334	4000
July, 09	6629	2600	3681	3800	2560	3500	2100	6950	159	4900
August, 09	2319	2750	3216	3740	2640	3125	2163	6500	180	4600
September, 09	4338	2900	3070	3700	3025	3125	2318	5250	210	4500
October, 09	7919	3900	3018	3500	3210	3245	2605	5700	564	4550
November, 09	1223	4450	2900	3850	4160	2100	8935	2300	1117	4600
December, 09	1686	2100	2954	2750	3790	3065	7635	4500	1671	4300
January 10	4980	2200	2641	3000	3610	2954	4922	5500	556	3000
February 10	22068	2090	2613	2500	3390	3612	3346	5500	4310	3500
March, 10	87017	1900	7589	3000	3360	2905	3160	5400	1686	3900
April, 10	66464	1920	8815	2150	2740	3125	2391	6100	2100	4100
May, 10	27364	1930	8290	2700	2320	3875	2531	6300	1666	3800
Jun, 10	19978	2150	7775	2600	2190	3215	2335	6000	803	3700

Source:Krishi Upaj Mandi Samities  
(A: Arrivals and P: Wholesale prices)

KUMS(Crops)	Dewas (Gram)		Gorakhpur (Lentil)		Gajbasoda (Black gram)		Manawar (Green gram)		Chhindwara (Pigeon pea)	
	A	P	A	P	A	P	A	P	A	P
July, 10	21144	2160	5747	2700	2018	3900	1515	6000	270	4500
August, 10	10125	2350	5693	2200	2769	3256	2410	6300	607	3200
September, 10	3966	2600	4117	2400	2880	3415	3042	5250	248	3100
October, 10	6406	3650	2527	3000	5362	3146	3502	3600	203	3200
November, 10	1442	4400	1386	3800	14046	2900	9474	3220	225	3400
December, 10	1582	3200	1741	2400	12538	3146	8530	3500	1950	2600
January 11	2501	3300	2525	2000	5056	3087	4295	4200	2260	3000
February 11	5089	3150	2330	2200	4750	3098	4197	4500	2284	2900
March, 11	37344	2100	5653	2300	3624	3045	4110	3900	1458	3500
April, 11	24093	2200	7646	2000	3377	3058	1521	3800	1483	3800
May, 11	14876	2300	6369	2250	3378	3152	1515	4000	1926	4100
Jun, 11	10353	2300	5833	2200	2787	3025	1321	4670	333	4300
July, 11	4606	2500	5760	2100	1820	3900	1145	5600	151	5300
August, 11	4508	2700	5630	2100	3525	3258	1639	4500	474	4400
September, 11	5313	3000	4892	2200	5926	3365	1458	2800	796	3350
October, 11	5715	3000	2330	2400	19304	2766	4979	2100	373	3400
November, 11	1466	4200	1964	3850	18610	2980	9672	1800	402	3550
December, 11	2502	4150	2611	3200	15381	3164	7297	1850	1450	3200
January 12	2933	3000	4127	2150	9369	3033	5315	2450	1673	1950
February 12	16195	3200	3428	2150	8285	3022	4202	2550	5459	2800
March, 12	16418	2800	3290	2150	1210	3087	3050	2600	4733	2850
April, 12	13673	3000	9150	2050	517	3165	2987	4100	3093	3050
May, 12	12049	3250	7097	2700	1927	3296	2897	4000	1191	3200
Jun, 12	6966	3800	7039	2800	11496	3887	1365	4200	1001	3300
July, 12	2969	4300	6508	3000	1662	4100	1322	4800	201	6000
August, 12	1635	4400	5489	3200	4546	2897	2324	4200	250	3300
September, 12	1313	4500	3027	3200	4542	2854	2484	3900	893	3250
October, 12	1217	4600	2820	3500	14704	2564	3252	3100	695	3275
November, 12	1201	4800	2537	3700	28237	2174	10622	2100	497	3350
December, 12	2258	4700	3711	3250	14076	2300	9972	3950	1298	3425

Source:Krishi Upaj Mandi Samities

(A: Arrivals and P: Wholesale prices)

KUMS(Crops)	Dewas (Gram)		Gorakhpur (Lentil)		Gajbasoda (Black gram)		Manawar (Green gram)		Chhindwara (Pigeon pea)	
	A	P	A	P	A	P	A	P	A	P
January 13	8458	3300	1480	2800	6941	2798	3188	5000	2200	2650
Februarys 13	10444	3500	1613	2900	4300	2736	2575	5100	4287	2200
March, 13	22814	2200	1695	3050	3386	2744	2530	5300	3779	3200
April, 13	22806	2300	23010	2700	3440	3259	2795	5100	1148	3900
May, 13	11585	2450	22064	3400	2917	3265	2830	5500	504	3900
Jun, 13	10356	2500	7685	3600	2895	3687	2117	4900	450	4400
July, 13	5439	2860	17752	3700	2657	4000	2116	5950	235	5800
August, 13	4173	2890	8645	3700	2627	3369	2530	4800	260	5500
September, 13	5236	2990	4248	3800	3049	3292	2250	4400	643	4600
October, 13	7633	3500	3257	3700	5424	3254	9025	4450	915	4600
November, 13	3210	3900	2501	4100	12044	2950	12053	2950	1050	4640
December, 13	6390	3100	3098	4000	9049	3025	9112	4300	1745	3650
January 14	5802	2300	1920	3900	2575	3188	5605	4200	1195	2900
February 14	12348	2400	3155	3600	2542	3196	5238	4300	5543	2800
March, 14	24489	2250	4389	3300	2483	3124	4812	5000	3647	3500
April, 14	22590	2400	15050	3200	2373	4596	4525	5400	2088	3500
May, 14	20134	2550	12686	3200	1820	4587	4216	5400	699	3400
Jun, 14	10005	2600	6272	3900	1770	4578	2528	5500	202	3350
July, 14	10000	2900	7586	3900	1374	4900	2220	6350	51	5100
August, 14	9007	3300	4182	4000	1450	4321	2454	5600	67	4000
September, 14	8474	3900	3249	4600	3879	4456	2671	6000	133	4200
October, 14	6806	4200	2249	4500	5930	4896	4159	5270	198	4000
November, 14	3702	4400	1921	4800	19449	2750	11246	3550	264	3900
December, 14	5783	2500	2098	3500	13344	3100	9027	4900	966	3800
January 15	2706	3100	1996	4000	2675	4512	7604	3600	3799	3000
February 15	3397	3000	1991	3000	2611	4439	6054	4200	4990	2900
March, 15	61883	2850	4721	2650	2202	4398	5075	4200	4615	4500
April, 15	52863	2900	12160	2600	2245	7915	3115	4150	2641	4250
May, 15	22000	4000	10216	2900	2184	7985	2913	4100	294	4400
Jun, 15	8607	3600	7412	5500	1797	7856	2885	4050	10	4501

Source:Krishi Upaj Mandi Samities  
(A: Arrivals and P: Wholesale prices)

KUMS(Crops)	Dewas (Gram)		Gorakhpur (Lentil)		Gajbasoda (Black gram)		Manawar (Green gram)		Chhindwara (Pigeon pea)	
	A	P	A	P	A	P	A	P	A	P
July, 15	4234	3600	7442	5600	1694	8000	2429	6202	53	6900
August, 15	4211	3600	2735	5700	1843	7258	3164	4600	213	4450
September, 15	3554	4000	2835	6400	5947	7963	3251	3937	422	4200
October, 15	3008	4500	2443	6500	9250	7545	5166	4350	632	4850
November, 15	2459	4600	1440	6500	19425	3050	11216	3232	841	4600
December, 15	2963	4400	2550	4900	15385	3265	10919	3530	1051	4500
January 16	2978	4000	2184	4600	2444	7896	4021	4050	1210	4000
February 16	12384	4000	2476	4200	2369	7950	3351	4400	8978	3200
March, 16	29713	2300	3175	2900	2106	7998	2597	4500	7981	4600
April, 16	22506	2900	4602	2800	2019	7039	1844	4600	8012	4600
May, 16	19841	3500	3537	5000	1921	7085	1690	4655	2779	4375
Jun, 16	14320	5000	2941	5000	1622	7286	1634	4565	2113	4450
July, 16	7968	5800	2125	5100	1264	7375	1550	5255	65	6700
August, 16	6699	5900	3006	5220	1751	7123	1956	4690	143	4650
September, 16	4508	6500	3165	4500	4632	7145	2515	4165	1215	4550
October, 16	4291	6980	1892	4300	16524	7248	5106	4065	4523	4440
November, 16	2234	7220	1415	5500	19543	3156	12104	3205	2426	4500
December, 16	2308	6800	1967	4400	11793	3499	9886	3400	2306	4500
January 17	13954	6000	2138	3600	4327	7085	5226	4582	2220	4050
February 17	18822	3900	3271	3520	4072	7083	5118	4822	2105	3250
March, 17	65082	3200	4283	3950	3275	7035	4216	4065	2075	4275
April, 17	53311	3600	6815	3000	3081	6000	3170	4500	2007	4200
May, 17	26118	4500	1603	3600	2986	5510	2189	4031	1663	4150
Jun, 17	25936	4830	3294	3032	2101	5800	2109	3800	411	5500
July, 17	19903	4980	2728	3120	1906	6500	1852	5897	85	7900
August, 17	10670	5120	3391	3022	4209	4000	1912	4600	172	4850
September, 17	6192	5800	1387	3138	4204	4806	1920	3850	193	4750
October, 17	6066	6800	1487	3036	8308	4100	7075	3950	224	3700
November, 17	5002	7000	1329	4900	18075	3400	14564	2700	390	4701
December, 17	10501	5200	1677	2794	12090	3560	10264	2950	910	4881

Source: Krishi Upaj Mandi Samities  
(A: Arrivals and P: Wholesale prices)

## **Plagiarism Report**

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