

# To Study the Instability and its Causes in Production of Major Pulse Crops in Rajasthan

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## ABSTRACT

The study was conducted the growth of area, production and productivity of major pulse crops i.e. gram, lentil, black gram, green gram and pigeon pea crops in Rajasthan. The study was based on secondary data from 1988-89 to 2017-18. Instability in area, production and productivity of selected pulse were worked out for entire period of analysis by Cuddy- Della Valle index and to measure the cause of instability with respect of selected pulse crops i.e. gram, lentil, black gram, green gram and pigeon pea in Rajasthan, acreage response function (log linear function) and yield response function have been used. The study 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 medium instable. In the mean, time productivity of lentil was very less instable. Gram and green gram 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 and green gram in Rajasthan. while quite responsive to lagged area under lentil, black gram and pigeon pea crop in Rajasthan. It means the increase in area of lentil, black gram and pigeon pea crops in last year season, there is tendency to increase the area under lentil, black gram and pigeon pea in Rajasthan. 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.

**Keywords:** Instability, acreage response function and yield response function

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).

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The Food Security Act-2013 mandatorily contemplates the right to nutritional security as well the gov't'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 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. (Source: Ministry of Agriculture and Farmers Welfare, DAC and FW, 2018).

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).

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).

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 (0.59 mt), 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).

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.

## MATERIALS AND METHODS

The study was based on secondary data collected from different sources i.e. Directorate of Agriculture and cooperation, GOI, Directorate of pulses development Bhopal, various issues of Agriculture Statistical Year Book and Agriculture Statistics at a Glance, etc. The time series data of area, production and productivity of selected pulse crops have been taken for 30 years from 1988-89 to 2017-18. Instability in area, production and productivity of selected pulse were worked out for entire period of analysis by Cuddy- Della Valle index and to measure the cause of instability with respect of selected pulse crops i.e. gram, lentil, black gram, green gram and pigeon pea in Rajasthan, acreage response function (log linear function) and yield response function have been used.

### Instability

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

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

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

$R^2 = \text{ESS}/\text{TSS}$  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

### (i) Causes of Instability in Area

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

### 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

## RESULTS AND DISCUSSION

**Instability:** The instability in area, production and productivity of selected major pulse crops i.e. gram, lentil, black gram, green gram and pigeon pea for the study period from 1988-89 to 2017-18 were calculated. The result of instability for selected pulse crops of Rajasthan were presented in the table 1 to 3.

### 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 1 and Fig. 1. 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 1 Fig. 1. 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 1 and figure Fig. 1. 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 1 and Fig. 1. 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

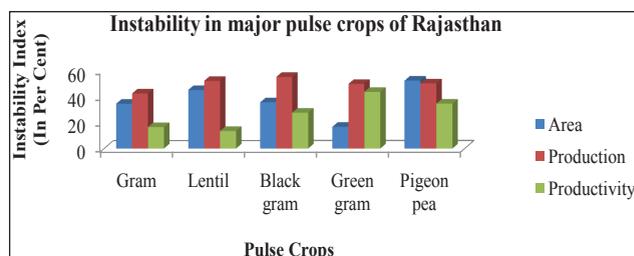
findings were also presented by Netharvadi and Yeledhalli(2016) in area, production and productivity of sesame crop in Bengaluru Division.

**Pigeon pea:** The results of instability in area, production and productivity of pigeon pea are showed in Table 1 and Fig. 1. 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 1:** 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.



**Fig. 1:** Instability in area, production and productivity of Major pulse crops in Rajasthan

### 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 2. 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.

**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 2. 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.

**Black gram:** The output of causes of instability in black gram area is presented in Table 2. 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.

**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 2. 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.

**Table 2:** 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
Constant ( $B_0$ )	0.227 (0.561)	-2.426 (1.066)	0.609 (1.432)	-0.867 (0.854)	-1.125 (1.544)
$A_{(t-1)}$	0.298 (0.191)	0.523** (0.249)	0.674 (0.208)	0.924 (0.074)	0.709* (0.216)
$C_t$	—	—	-0.454 (0.622)	—	—
$C_{(t-1)}$	-1.000** (0.577)	-0.488 (0.883)	-0.379 (0.495)	-0.692 (0.311)	-0.327 (0.555)
S	0.102 (0.092)	0.050 (0.139)	0.146 (0.139)	0.079 (0.086)	0.428 (0.150)
$S_{(t-1)}$	-0.034 (0.092)	0.032 (0.120)	0.102 (0.171)	0.066 (0.113)	0.012 (0.199)
R <sup>2</sup>	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

**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 2. 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.

### 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 3. 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 3. 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 3. 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 3. 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 3. 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 3:** Estimated yield response function (log linear form) of major pulse crops in Rajasthan (1988-89 to 2017-18)

Sl. No	Variable	Gram	Lentil	Black gram	Green gram	Pigeon pea
1	Constant ( $B_0$ )	-5.901 (3.569)	-0.987 (2.576)	-9.591 (4.726)	-13.190 (9.744)	-6.983 (6.333)
2	T (Time)	0.004** (0.002)	0.002 (0.001)	0.005** (0.002)	0.006 (0.005)	0.004 (0.003)
3	S	-0.004 (0.051)	-0.077** (0.037)	0.426* (0.110)	0.906* (0.227)	0.412* (0.147)
4	R <sup>2</sup>	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.

## CONCLUSION

The study 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 medium instable. In the mean, time productivity of lentil was very less instable. Gram and green gram 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 and green gram in Rajasthan. While quite responsive to lagged area under lentil, black gram and pigeon pea crop in Rajasthan. It means the increase in area of lentil, black gram and pigeon pea crops in last year season, there is tendency to increase the area under lentil, black gram and pigeon pea in Rajasthan. 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.

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