An Economic Analysis of Production of Pulses in India

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ABSTRACT

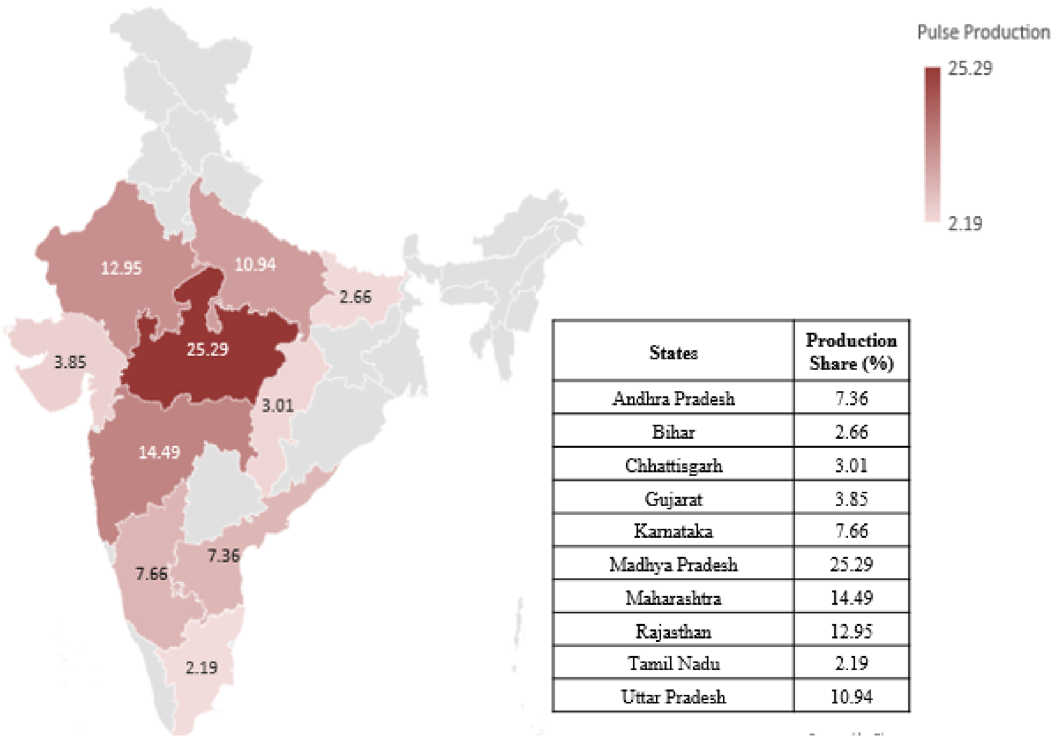
This study has made comparison between trends in area, production, and yield of major pulses in India through growth rate and instability analysis for the last 28 years from 1992-93 to 2019-20, which were further divided into two sub-periods characterising the periods of before and after 2006-07. The growth rates were calculated by fitting the semi-log linear growth function and instability was analysed with the help Cuddy Della Valle Index (CVDI) for the total pulses of India. Along with that tries to analyse long-run relationship between production, area of cultivation, and distribution of High Yield Variety (HYV) seeds using Johnson Cointegration test and used technique of impulse response function has been used to know the nature of impulse response of selected variables to production. The results have shown significantly positive trend in area, production and yield of major pulses over the period of time. In comparison between sub-periods; Compound annual growth in area, production and yield shown positive trends in post 2006-07 compare to before one. But yield growth rate was found higher than the growth rate in area implying that area allocation under pulses is increasing poorly even in sub-period II while improvements in yield are there. Even across the states; Rajasthan, Madhya Pradesh, Tamil-Nadu performed better in terms of growth in three Components. Main factors responsible includes improvement in technologies and government support through schemes such as NFSM, A3P. In case of stability, production of pulses are low and moderate in sub-period I and II which are 8.83% and 10.05% respectively. Whereas instability is much lower in case of area of cultivation and productivity. And also found existence of long run relationship between the area of cultivation, distribution of seeds and production of pulses.

Key Words: Pulses, Compound Growth rate, Instability, Cuddy Della Valle Index, Johansen Co-integration Test.

Introduction

Pulses are key sources of proteins for the vegetarians in India. Its complement the staple cereals in the diets with proteins, essential amino acids, vitamins and minerals. It contains 22-24% of protein, which is almost more than double the protein in wheat and three times that of rice. Pulses provide significant nutritional and health benefits, and are known to reduce several non-communicable diseases such as colon cancer and cardiovascular diseases (Curron, 2012). It can be grown in a variety of climatic settings, but it thrives most in a mild, cool, and rather dry climate with temperatures between 20 and 25 degrees Celsius and 40 to 50 centimetres of rainfall and play important role in crop rotation, mixed and inter-cropping, maintaining soil fertility through nitrogen fixation, release of soil-bound phosphorus, and thus contribute significantly to sustainability of the farming systems. Major pulses grown in India include chickpea, pigeonpea or red gram, lentil which are mostly grown in two seasons: (i) The Kharif (June-October), and (ii) Rabi (October-April). Chickpea, lentil and dry peas are grown in the rabi season, while pigeonpea, urdbean, mungbean, and cowpea are grown during the kharif season.

Figure 1 Pulses production (State-wise share in %)



States	Production Share (%)
Andhra Pradesh	7.36
Bihar	2.66
Chhattisgarh	3.01
Gujarat	3.85
Karnataka	7.66
Madhya Pradesh	25.29
Maharashtra	14.49
Rajasthan	12.95
Tamil Nadu	2.19
Uttar Pradesh	10.94

Source: Authors' calculations; Handbook of Statistics, RBI.

The largest producer, India accounts for about 25% of global production. More than 90% of the land in the nation and the production of pulses are in Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Karnataka, Bihar, Gujarat, Chhatisgarh, Tamilnadu and Andhra Pradesh. Along with largest producer; India is foremost consumer (27 per cent of world consumption) and importer too in the world. There exist a huge gap between demand and supply of pulses in India and about 20 per cent of its total demand which is met by imports. Pulses contributes around 14% to agricultural imports basket. Therefore, the production of pulses needs to be increased on sustainable basis to meet raising domestic necessity and projected production of pulses of 32 million tonnes of pulses by 2030 (PULSES IN INDIA: RETROSPECT AND PROSPECTS, 2016)(2). A high growth rate and low instability in production are needed for sustainable agricultural performance and has important implications for policy makers. In this regards it is important to study the growth and instability in pulses production. Sharma (Lal, 2013) has examined the growth of pulse production in India for the period 1980-81 to 2008-09 and found a positive percent change in area, production and yield of pigeon pea, chickpea and total pulses except in case of lentil. With consideration of the necessity of pulses, the present study was carried out to examine the growth and instability in area, production and yield of pulses in India. Along with show long run relationship between production, area and distribution of seeds.

OBJECTIVES

1. To explore and compare the spatial and temporal pattern of area, production and productivity of pulses in India.
2. To estimate the instability in area, production and yield of pulses in India.
3. To find out existence of long run relationship between production, area of cultivation and distribution of seeds.

REVIEW OF LITERATURE

Devegowda SR et. al (2018) examined the trends in growth of major pulses in India by using semi-log linear model in period 1990 to 2015. He divided the overall period into three decades to study decadal growth over the period of time in production, area, productivity and value of output for major pulses. They reported Compound growth rate (CGR) of 1.27, 2.34, 1.08, and 8.94 for grams, 0.49, 1.13, 0.47 and 7.66 for arhar, 0.21, 0.51, 0.30 and 8.21 for moong, 0.93, 1.19, 0.26 and 8.97 for masoor, -4.90, -4.08, 0.83 and 4.69 for horse gram, 0.03, 0.83, 0.80 and 8.47 for uad, 0.28, 1.41, 1.05 and 8.40 per cent for total pulses in area, production, yield and value of output observed respectively for entire period.

Anwesha Dey, M. Anoop and Yash Gautam (2020) studied the trend and instability in wheat area, production and productivity in Uttar Pradesh state for period of 1950-51 to 2015-16. They used Compound annual growth rate and coefficient of variation to show trend and instability respectively in area, production and yield of wheat. The analysis of instability showed that production instability (73.7 per cent) was higher compared to area (32 per cent) and yield instability (43 per cent) throughout the whole period.

Nasim Ahmad et. al (2020) analysed growth along with instability in area, production and productivity of sugarcane farming in major sugarcane growing states of India for the period from 2000-01 to 2015-16 by using Compound growth rates, instability indices using formula suggested by Cuddy- Della Valle. They found out area, production and productivity of sugarcane went up during the period of investigation at national level. Similar result was also observed in case of growth rates of sugarcane crop which were found positive and encouraging. The area under sugarcane was found stable in the states like Uttar Pradesh, Uttrakhand and Gujarat on the other hand the yield of sugarcane recorded almost stable in Uttar Pradesh, Uttrakhand and Tamil Nadu.

Sanjay, M. Seidu and K.K. Kundu (2020) examined growth and Instability in Cotton Cultivation in Northern India based on secondary data from 1966-67 to 2013-14. The study analysed the trends, growth and instability in area, production and yield of cotton in Haryana using semi-log linear function, compounded annual growth rate and Cuddy Della Valle Index. It revealed a positive significant trends with low annual growth rates of area of harvest (2.00%), production (3.99%) and yield (1.66%). Instability was high and also inclined at an annual rate of 30.96% in area, 25.76% in production and 28.04% productivity respectively.

Rakesh Sihmar (2014) conduct district level analysis of Growth and Instability in agricultural Production in Haryana and concluded that some crops like rice and wheat show a very satisfactory performance in their production in all the three periods (1980-81 to 1989-90, 1990-91 to 1999-2000 and 2000-01 to 2006-07) with the help of compound annual growth rate and CVDI. On the other hand, crops like Gram, Massar, Maize, Sesamum, groundnut has showed unsatisfactory performances in their production. All these crops showed significantly negative growth rate in production over the periods. In the case of total pluses, the production has shown a declining trend over the periods and Gram showed highest declining trend in both, production and area. The instability has been low and also declined over the time in wheat and rice.

Asha Bisht and Anil Kumar (2018) examined trends in area, production and yield of major pulses in India through growth rate and instability analysis for the last 20 years from 1996-97 to 2015-16, which were further divided into two sub-periods that are before and after NFSM. The growth rates and instability were calculated by using the exponential growth function and Cuddy Della Valle index respectively for the five major pulses of India and pulses as a whole. They have shown growth rate of 2.14 percent in pulses production during period I. This growth rate is significantly higher in the sub period II. The area and yield under pulses have also shown a marginal but significant growth rate of 0.44 and 1.19 percent respectively.

Narayan Sharma Rimal et. al (2015) analysed the patterns and sources of growth in pulses production along with future growth performance. They focused on long run relationship between area expansion, prices and production of pulses. Study found that in the short-run, to boost pulses production, the policy should address the non-price constraints such as irrigation, access to credit and input supply. However, the growth in pulses production in the long-run must come from technological changes.

Aneesha Mech (2017) analyses growth trend, instability and its determinants in Assam for production of rice for the period 1972-73 to 2014-15. He used methodology semi-linear function, coefficient of variation for compound annual growth and instability respectively. Also used Johansen co-integration test for estimate impact of the determinants on rice yield. The author uses yield, area under cultivation, fertilizer, HYV usage, and temperature and rainfall inputs in co-integration test. He found that except rainfall all inputs showed positive impact on rice production.

Subha S.S. (2021) tries to show long run relationship between area and production of food grain crops for the period 1950-2018 using co-integration approach. He reveal that a log-run relationship between the area under the food grain crops and its production. The finding shows that as the 1 % increase in area under the crop cases nearly 6 % increases in production.

DATABASE AND METHODOLOGY

1. Pattern of growth and instability

The study uses time-series data from secondary sources for 28 years (1992-93 to 2019-20) pertaining to area under cultivation, production and productivity of pulses on state wise across the country along with itself were sourced for the study. The data were sourced from various issues of published sources such as Reserve Bank of India's Handbook of statistics on Indian economy and states; Agricultural Research data book and other published sources.

In order to determine the trend, growth rate, instability on area under cultivation, production and productivity of crop for the period 1992-93 to 2019-20 by employing analytical techniques such as arithmetic mean, standard deviation and coefficient of variation.

A parametric model such as semi logarithmic function was fitted to estimate compound growth rate while the Cuddy-Della Valle index was specified to estimate instability in area, production and productivity.

Model specification of trend and compound growth rate

Similar to the studies of (Wassim (2001) and Laxmanan et al. (2005)) the study specified growth rates of area; production and productivity using semi-log linear function. Since the dependent variable(s), area/production/productivity (Y) grows exponentially at an unknown rate (r). Therefore, the study specified the models below to estimate trend (equation 1), growth rates (equation 1 and 1.1) of area; production and productivity of the selected crops.

$$\log Y_i = \beta_0 + \beta_1 t_1 + \mu_i \qquad (1)$$

$$\text{Therefore } r = (\text{Anti} \log \beta_1 - 1) \times 100 \qquad (1.1)$$

Model specification of instability

The study also assessed the index of instability of area, production and productivity of the pulses by using Cuddy-Della Valle index. The coefficient of variation around the trend (CV_t)

instead of co-efficient of variation around the mean (CV) had been used. Thus, a log-linear trend model and CV were fitted to estimate instability. Cuddy Della Valle Instability index (Cuddy & Della, 1978 and Della, 1979) is a modification of CV to accommodate for trend, which is commonly present in time series economic data. This method is superior over other scale dependent measures such as standard deviation or Root Mean Square of the errors (RMSE) obtained from the fitted trend lines of the raw data, and hence suitable for cross comparisons.

The same semi-log linear trend model that was specified for the indices of area, production and productivity in equation (1) was again used in the estimation process of instability thus,

$$\log Y_i = \beta_0 + \beta_1 t_i + \mu_i$$

Where:

Y_i = Dependent variable specifying Area (000 ha) or production (000 Tonnes) or productivity (kg/ha)

β_0= the intercept, β_1 = the parameter to be estimated,

t_i= time in years and μ_i = the error term.

The index of instability (i.e. the Cuddy-Della Valle index which corrects the coefficient of variation) was constructed by considering the R^2obtained in the log linear trend model and the coefficient of variation around the trend. The Cuddy-Della Valle index was constructed as follows:

$$CV_t = CV \times \sqrt{1 - R^2_{\text{Adjusted}}} \qquad (2)$$

Where;

CV_t = Coefficient of variation around the trend,

CV = Coefficient of variation around the mean,

R^2_{Adjusted} = coefficient of determination from a time-trend regression.

From equation (2), the co-efficient of variation (CV) around the mean was multiplied by the square root of the proportion of the variation, which was unexplained by the trend equation;

$$\log Y_i = \beta_0 + \beta_1 t_i + \mu_i$$

$$CV = \frac{SD}{AM} \times 100 \qquad (3)$$

Where:

SD = Standard deviation of area (000 ha) or production (000 tonnes) or productivity (kg/ha),

AM = Arithmetic Mean of area (000 ha) or production (000 tonnes) or productivity (kg/ha).

For the purpose of analysis, the degree of instability is divided in three groups which are given below;

Sr. No.	Instability Index values (in per cent)	Ranges of instability
1	Low degree of instability	0 to 10
2	Moderate degree of instability	10 to 20
3	High degree of instability	Greater than 20

SUPPLY RESPONSE

Most of the time series have unit root problem and are often suspected to be non-stationary. To overcome this problem, we tested for stationarity by using Augmented Dickey-Fuller (ADF) test. The method of Co-integration and Error Correction Mechanism (ECM), when combined with the partial adjustment and adaptive expectation of farmers, gives the distinct long-run and short-run supply elasticities. This technique can be used with non-stationary time series to avoid spurious regression.

STATIONARITY

In time series analysis, Kwiatkowski–Phillips–Schmidt–Shin (KPSS) and Augmented Dickey-Fuller (ADF) are the two tests used to check stationarity. But ADF have an advantage over KPSS Test. Therefore, our study uses Augmented Dickey-Fuller (ADF) to calculate stationarity.

The ADF test is denoted by Equation (3):

$$\Delta X_t = \mu_0 + \mu_1 t + (\delta - 1)X_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta X_{t-1} + e_t \text{ ----- (3).}$$

Where, e_t is the pure white noise error-term and k is the chosen lag length.

The following are null and alternative hypothesis

Null Hypothesis: H_0: $\mu_0 = 0$

Alternative hypothesis: H_0: $\mu_0 \neq 0$

DECISION RULE: We reject the Null Hypothesis when p value is less than the 0.05 ($p<0.05$) at 5% level of significance which implies the existence of unit root in the variable.
If H_0 is rejected, then the series (X) is stationary. If not, then first difference is taken to make it stationary.

CO-INTEGRATION

A co-integration analysis is the equation of long-run relationship among co-integrated series or the variables contained in X_t. The Johansen approach provides two test statistics for the number of cointegrating vectors given by the co-integration rank r: Trace and the Maximum Eigen Value statistics. When the co-integration rank r is equal to 1, the Johansen single equation dynamic modelling and the Engle-Granger approaches are valid. When r equals 1, the normalisation restriction for the parameters produces a unique estimate. When there are more than one co-integration equations, the Johansen approach is preferred over Engle-Granger approach.

Johansen approach Criterion:

Null Hypothesis: H_0= No Cointegration exist.
Alternative Hypothesis: H_1= Cointegration exist.
DECISION RULE: We reject the Null Hypothesis when p value is less than the 0.05 ($p < 0.05$) at 5% level of significance.

VECM/VAR

Once the stationarity of individual series is established, linear combinations of integrated series are tested for cointegration. If these are found cointegrated, it implies a long-run equilibrium relationship. The analysis is carried out by applying Johansen co-integration test which involves the VECM framework of the following form:

$$\Delta X_t = c + \sum_{i=1}^{k} \alpha_j \Delta X_{t-1} + \delta D_t + \gamma t + \lambda \varepsilon_{t-1} + \nu_t \qquad (4)$$

Where, $\varepsilon_{t-1} = lnX_{t-1} - \sum \beta_j X_{jt-1}$ (error/ equilibrium correction-term)
D_t is a vector of stationary exogenous variables; δ is vector of parameters of exogenous variables; and λ is the coefficient of error correction- term ε_{t-1}.

Once the co-integration among the variables is confirmed, the ECM is used to analyze the short-run and long-run dynamics. The ECM is dynamic in the sense that it involves lags of the dependent and explanatory variables, and thus captures short-run adjustment to the changes in adjustments into past disequilibria and contemporaneous changes in the explanatory variables and also displays the cointegrating relationship between or among variables.

IMPULSE RESPONSE FUNCTION (IRF)

To understand the impact of one variable on other. IRF measures the responsiveness of dependent variable to the shocks on the independent variable in the VAR model. It delineates the path the dependent variable will take to shock given to the independent variable. To estimate the shock the VAR is expressed as a vector moving average (VMA) and the shock subsides gradually.

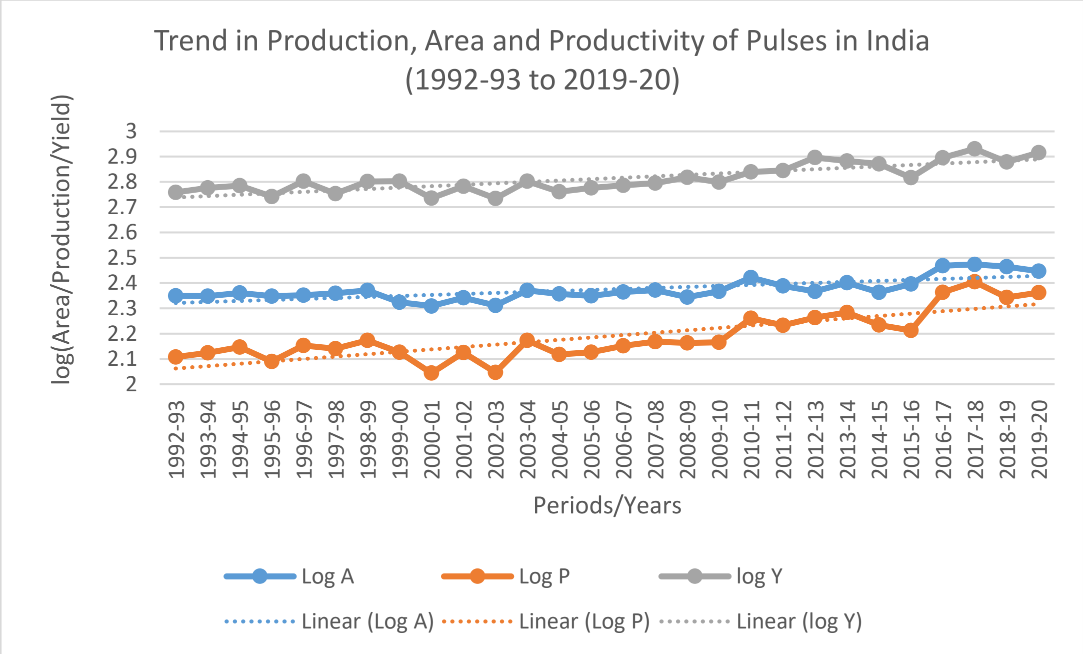
RESULTS AND DISCUSSION

1. **Patterns and Trends in performance of Pulses in India (1993-2020)**

   Figure 1 depicted the trends in area, production and productivity of Pulses. The trends of the performances of Pulses showed slight positive irregular growth throughout the entire period based on the log linear graphs in Figure 1. However, according to *N.S. Rimal et.al (2015)* the continuous improvement in pulses production in post reform period was mainly due to yield improvement in support with area expansion and rainfall.

Figure 2 Trend in Production, Area and Productivity of Pulses in India

(1992-93 to 2019-20)



Source: Author's calculation based on data obtained from published sources. (Have to put equations in graph)

2. **Compound growth rates of area, production and productivity of pulses (1993-2020)**

   2.1.For India:

The compound growth rates of area, production and yield of pulses for the two different time periods (1993-2006 and 2007-2020) for entire country analysed by the log linear model were presented in Table 1. The study identified significantly negative growth in area, production and positive in yield for 1993-2006. While showed positive in all of these three in 2007-2020. It was found that during the 1993-2006; the area, production decreased and yield increased at rate of 0.069, 0.080 and 0.006 percentage respectively. But in 2007-2020 area, production and yield increased at 0.83, 1.77 and 0.93 percentage respectively. As per (KUMAR, 2018) initiative taken by the government in the form of NFSM to increase the production of pulses has responded and growth rates have been found higher in the post-2007.

Table 1 CAGR for Pulses (1993 to 2020)

PERIOD	AREA	PRODUCTION	YIELD
1993-2006	-0.069	-0.080	0.006
2007-2020	0.835	1.775	0.933

2.2. Across the states:

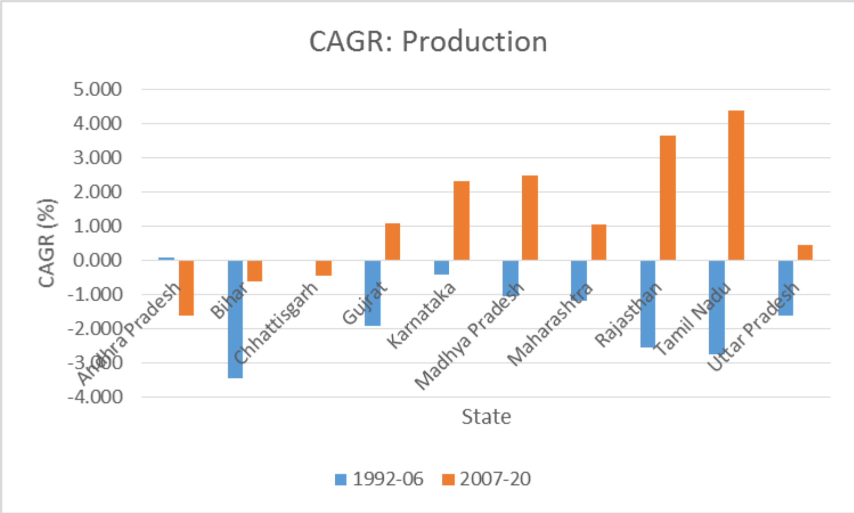
In India, production of pulses is concentrate in a few states in India. The states of Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Tamilnadu and Karnataka account for more than 90 per cent of the total area as well as production of pulses. Madhya Pradesh has a higher share in the pulses (25%). It alone accounts for one-fourth of the total production. The compound growth rate for the area, production and yield were calculated with the help of semi-log function.

State wise comparison of CAGR between sub-periods (1992-06 and 2007-20):

2.2.1. On the basis of Production:

On comparison across the states; all nine states except Andhra Pradesh showed negative compound growth rate in in sub-period I (1992-2006) while in sub-period II (2007-20). Tamilnadu, Rajasthan and Madhya Pradesh are showing positive growth rate. We some states like Tamilnadu and Rajasthan has shown drastic shifting in growth rate which are from -2.7% to 4.3% and -2.5% to 3.6% respectively. Main factors responsible for the scenario are technological advancement over the period, government intervention through different schemes such as National Food Security Mission (NFSM), A3P (Accelerated Pulses Production Programme) etc. (R. Sangeetha, 2020).

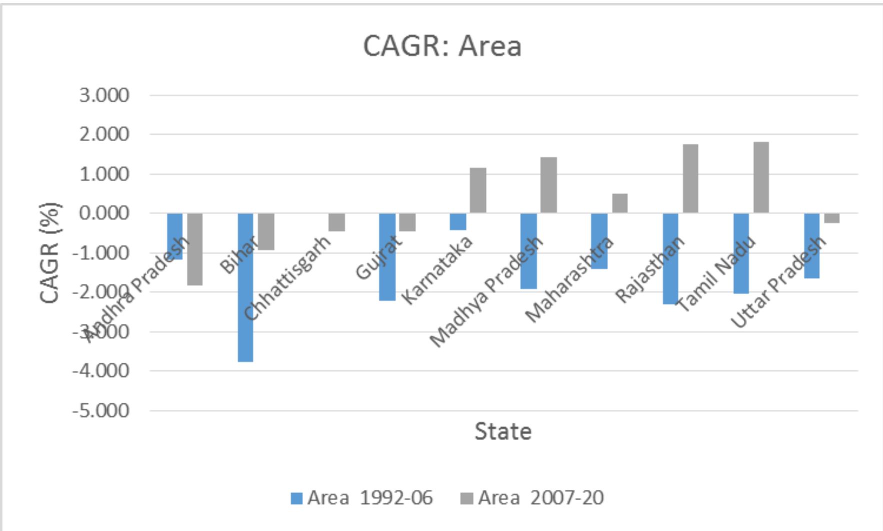
Figure 3.1 Trend in compound growth rate (CGR) of Production



2.1.2. On the basis of Area of cultivation:

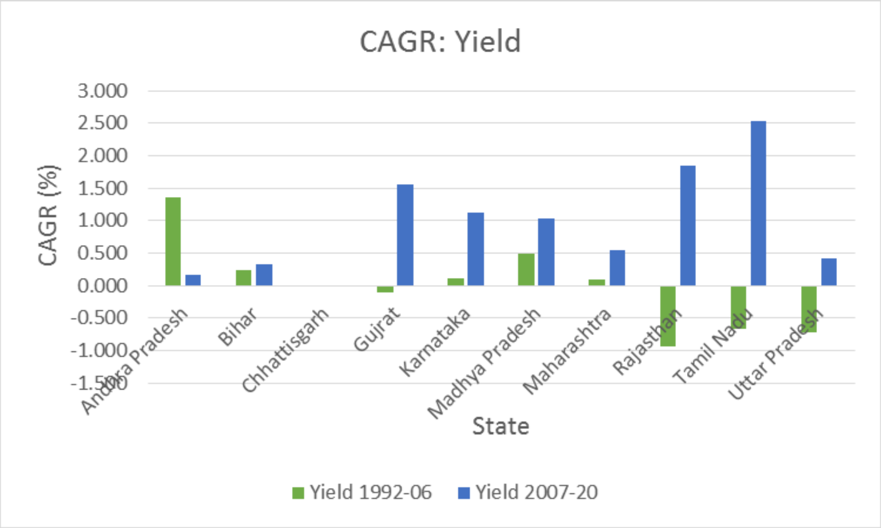
The performance of area cultivation of pulses production during sub-period I has negative in each major pulse production states. But announcement by government (including NFSM) in sub-period II has made positive impact in top three major producing states viz. Madhya Pradesh (1.41%), Rajasthan (1.74%) and Tamil Nadu (1.80%).

Figure 2.2 Trend in compound growth rate (CGR) of Area



2.1.3. On the basis of Yield (Productivity):

Figure 2.3 Trend in compound growth rate (CGR) of Productivity



For the both sub-periods; on comparison we can see positive compound growth in yield of pulses in sub-period II over period I in all ten states. Some states like Rajasthan (1.85%), TamilNadu (2.53%) performed extremely well in II period than first I. study of () detected that adoption of improved seeds and management practices are responsible for increase in production led to yield in Bundel Khand region. So, on account of government intervention through incentives are responsible to increase growth in productivity.

Table 2 Categorization of states as per the compound growth rate (total pulses) for the periods (1993-06 and 2007-20.)

Period	Area		Production		Productivity	
	Positive	Negative	Positive	Negative	Positive	Negative
1992-06		AP, BH, GJ,	AP	GJ, KT, MP,	AP, BH, KT,	RJ, TN, UP,
		KT, MP,RJ,		TN, RJ, UP.	MH, MP	GJ.
		TN, UP.				
2007-20	TN,RJ,MP,	AP, BH, CG,	TN, RJ,MP,	AP, BH, CG	TN, MP, MH,	CG
	KT, MH.	UP, GJ.	KT, MH, UP.		MH, AP, BH.	

Note: AP: Andhra Pradesh, BH: Bihar, CG: Chhattisgarh, GJ: Gujarat, KT: Karnataka, MP: Madhya Pradesh, MH: Maharashtra, RJ: Rajasthan, TN: Tamil Nadu, UP: Uttar Pradesh.

The categorization of states as per compound growth rate of total pulses for the period 1993 to 2020 has been represented in Table 4. We can see some states like AP, UP, BH were lagged in the growth of area expansion in post sub-period also. Whereas states like Madhya Pradesh, TamilNadu, Rajasthan has detected significantly positive growth. In case of production Gujarat, Karnataka, Madhya Pradesh has showed negative growth rate in 1992-93 to 2005-06; while same states performing much better in post period. The productivity scenario is much better in all states from 2006-07 to 2019-20 except Chhattisgarh.

3. **Instability of area, production and productivity of pulses for the periods (1993-2006 and 2007-2020)**

Details of instability in pulses area, production and yield in India for the periods (1993-2006 and 2007-2020) is presented in Table 4. It depicted a low level of instability in the area for the both Periods and the same pattern of instability was seen in the case of yield. It's found that low level of stability in 1993-2006 but moderate in 2007-20 which are 8.83% and 10.05% respectively in production. The main causes for this kind of scenario are climate changing pattern, technological constraints along with decreasing land water resources.(Mousumi Malo and Jayita Hore(~~combine~~)).

Table 3 Instability Indices of Pulses

PERIODS	AREA	PRODUCTION	YIELD
1992-06	4.36	8.83	5.82
2007-20	6.52	10.05	6.20

SUPPLY RESPONSE

STATIONARITY using Unit root test.

Unit root analysis is done for understanding the characteristics of the variables. Results of ADF test for at level and first difference are given in the Table 6. From Table 2 it is evident that the null of unit root is accepted at level and rejected at first difference by ADF unit root test under 5% level of significance. Since all variables are stationary at first difference let's proceed towards further analysis.

Table 4 Unit root test results

Variables	At Level		First Difference	
	t-Statistic	P.V.	t-Statistic	P.V.
Prod	-1.039971	0.7239	-5.296951	0.0002
ArCul	-1.40036	0.5671	-5.200776	0.0003
DistSeeds	1.105806	0.9964	-7.290402	0.0000

Prod: Production, ArCul: Area of cultivation, DistSeed: Distribution of seeds, P.V.: Probability Value ($p < 0.05$)
Source: Author's calculation using E views 10.

CO-INTEGRATION

Johansen co-integration test is used to check long-run co-integrating vector among the variables. Results of Johansen co-integration test is provided in Table 7. Results showed that there will be at least one long-run relationship among the variables.

Table 5 Johansen-Cointegration Result

Hypothesized No. of CE(s)	Eigen value	Trace value	0.05 Critical Value	Prob.**
None*	0.674610	36.20136	29.79707	0.0080
At most 1	0.361912	10.37858	15.49471	0.2527
At most 2	0.001961	0.045152	3.841466	0.8317

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level,
* denotes rejection of the hypothesis at the 0.05 level
** MacKinnon-Haug-Michelis (1999) p-values.
Source: Author's calculation using E views 10

VECM/VAR

Vector error correction (VER) will tell us after normalizing pulses production, how distribution of seeds and area of cultivation will influence production of pulses in the short run. Negative co-efficient of distribution of seeds and area of cultivation suggests that an increase in distribution of seeds and area of cultivation may not necessarily increase pulses production in the India. (Reason~~This may be due to the leakages in the subsidy distribution~~

system. But positive coefficient of agricultural credit suggests that an increase in agricultural credit is contributing positively to the agricultural)

Normalised Co-integrating Vector (Standard Error in the parenthesis)			
Prod	ArCul	DistSeeds	C
1.00000	-0.643311	-2.960529	36.72895

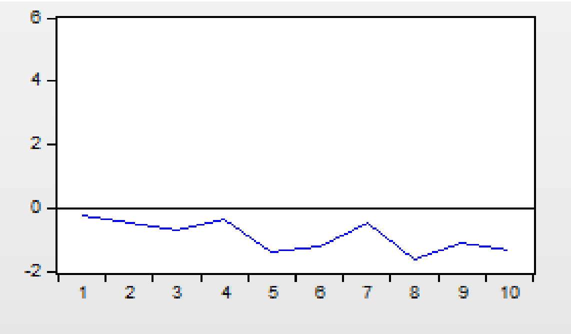
Prod: Production, ArCul: Area of cultivation, DistSeed: Distribution of seeds, C: Constant.

Source: Author's calculation using E views 10.

IMPULSE RESPONSE

Impulse response function will explain how a standard deviation shock to one variable will reflect in other variables in the short-run.

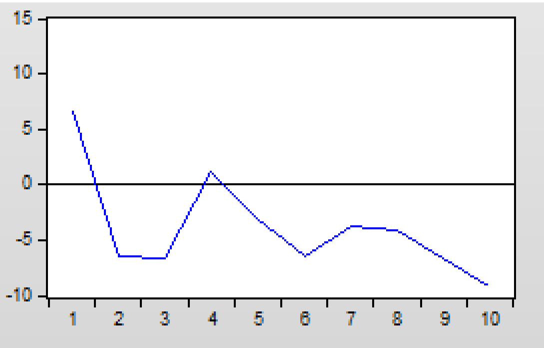
Response of dist. of seeds to Production



- Distribution of seeds doesn't respond to a positive shock in Production in the 1st period; continues to fall till 3rd period. Upticks in period 4, 7 and 9; but overall negative impulse observed.

- The possible reason can be increase in production due to eco-friendly practices. And also to rescue fertility of soil.

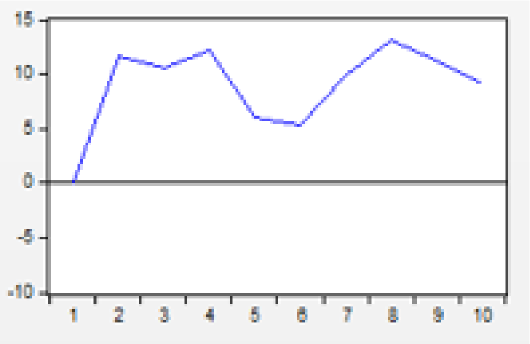
Response of Area of cultivation to production



- A positive impulse response is observed in period 1, which quick decline to negative range up to period 2 and constant to period 3, before recovering in period 4 which is slight positive.

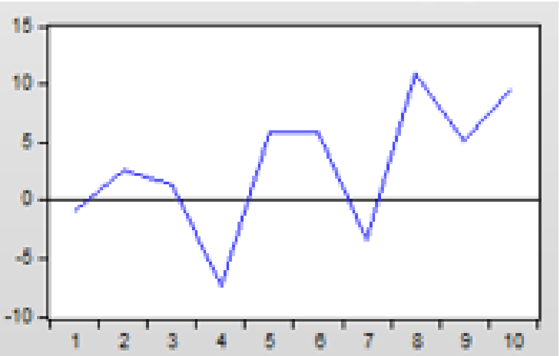
- In longer run, i.e., after period 5, the response is fluctuating but it is negative. Even in period 10 it drastically fall down.

Response of Production to Area



- Response in period one is mild, but continues to be positive throughout. Even in long run response suddenly increases.
- It shows increase in area will lead to increase in production. But other factors are equally responsible for that such as usage of fertilizers, modern technology.

Response of Area to of Dist. of Production



- Response in entire ten periods are fluctuated. From one to three; first in up then sharp down to four.
- Again quick increase in four to five then constant up to six. Then upward and positive consecutively from eight to tenth period.

Summary and Conclusions:

From the study it is concluded that over the period 1992-93 to 2019-20; the trend in compound growth rate in area, production and yield were found to be higher in 2007-20 than 1992-06. In India, government interventions through different schemes (National Food Security Mission, A3P) and incentives are responsible for this shift in growth rate Even across the states; Andhra Pradesh, Bihar, Uttar Pradesh, Gujarat showed significantly negative growth rate in cultivated area but Tamilnadu, Rajasthan, Madhya Pradesh, Maharashtra showed positive growth rate in production and productivity for both the sub periods. In case of stability, it's found that low level of instability in 1993-2006 but moderate in 2007-20 which are 8.83% and 10.05% respectively in production of pulses. While instability is much lower in case of area of cultivation and productivity across the major pulses producing states

Since a deliberate attempt to examine the long run relationship between area of cultivation, distribution of seeds and production of pulses over the period 1992-93 to 2019-20.Johansen Co-integration test suggests that there existence of long run relationship among the area of cultivation, distribution of seeds and production of pulses. Vector error correction and impulse response function suggests that it’s the area of cultivation, distribution of seeds which are positively contributing to the production of pulses.

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APPENDIX

Table A6. Share of states in total area, production and CAGR of pulses (A.S. of 1993-2006).

	1992-2006				
State	Production		Area		Yield
	A.S.	CAGR	A.S.	CAGR	CAGR
Andhra Pradesh	7.397	0.098	8.184	-1.180	1.369
Bihar	5.170	-3.444	3.902	-3.780	0.245
Chhattisgarh					
Gujarat	3.647	-1.907	3.579	-2.205	-0.101
Karnataka	5.546	-0.415	8.150	-0.429	0.117
Madhya Pradesh	23.659	-1.047	20.513	-1.908	0.484
Maharashtra	14.295	-1.184	15.434	-1.407	0.093
Rajasthan	10.872	-2.536	15.407	-2.314	-0.944
Tamil Nadu	2.090	-2.738	2.873	-2.052	-0.663
Uttar Pradesh	18.157	-1.601	12.409	-1.643	-0.712
Others	9.166		9.550		

Note: A.S.: Average Share in percent, CAGR: Compound Annual Growth Rate.

Table A7. Share of states in total area, production and CAGR of pulses (A.S. of 2007-20).

	2007-2020				
State	Production		Area		Yield
	A.S.	CAGR	A.S.	CAGR	CAGR
Andhra Pradesh	7.355172	-1.62614	6.684119	-1.82491	0.173124
Bihar	2.661203	-0.60401	2.137014	-0.9396	0.338156
Chhattisgarh	3.010624	-0.44693	3.370301	-0.44499	-0.00196
Gujrat	3.848507	1.095315	3.191081	-0.45191	1.554966
Karnataka	7.659306	2.297424	10.2887	1.15862	1.123105
Madhya Pradesh	25.28836	2.4637	21.1392	1.416691	1.032851
Maharashtra	14.48789	1.063487	14.77669	0.505811	0.553716
Rajasthan	12.95477	3.628964	16.94229	1.742977	1.852668
Tamil Nadu	2.18696	4.385501	2.76831	1.803202	2.539139
Uttar Pradesh	10.94338	0.442812	9.307393	-0.23912	0.418838
Others	9.603827		9.394898		

Note: A.S.: Average Share in percent, CAGR: Compound Annual Growth Rate.

Table A4 for impulse response function

Response of PRODUCTION:

Period	PRODUCTI...	DISTRIBUT...	AREA
1	11.93254	0.000000	0.000000
2	-4.097652	7.689844	11.71104
3	-5.533470	0.267566	10.57280
4	-0.701737	-1.648719	12.19319
5	-0.201473	6.153504	6.122673
6	-6.427709	10.19067	5.261480
7	-2.006969	2.185209	9.814340
8	-4.332268	10.89943	13.04079
9	-8.283446	14.76681	11.30833
10	-7.044384	10.02111	9.057647

Response of DISTRIBUTION_OF_SEEDS:

Period	PRODUCTI...	DISTRIBUT...	AREA
1	-0.264354	2.379986	0.000000
2	-0.463794	1.874154	0.501479
3	-0.713180	2.740471	0.311799
4	-0.370311	2.801205	2.097622
5	-1.394304	2.832942	1.579728
6	-1.233437	3.769180	1.503179
7	-0.459112	1.788878	2.418813
8	-1.646681	4.274543	1.271559
9	-1.090999	3.128484	2.595155
10	-1.326019	2.404779	1.578822

Response of AREA:

Period	PRODUCTI...	DISTRIBUT...	AREA
1	6.660975	-0.899041	9.562708
2	-6.529983	2.672424	14.73117
3	-6.724808	1.398071	10.18372
4	1.139823	-7.348465	12.87298
5	-3.033167	5.802052	6.391054
6	-6.387649	5.767692	10.45824
7	-3.805367	-3.400991	9.985157
8	-4.108032	10.93090	12.16630
9	-6.736957	5.171377	14.02993
10	-9.238714	9.687838	6.647470

Figure 4 Graphs for impulse response function