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Review Article

GROWTH AND INSTABILITY IN AREA, PRODUCTION AND PRODUCTIVITY OF SOYABEAN IN INDIA

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Abstract: This paper analyzes the growth and instability in terms of area, production and productivity of soybean crop in India. For the analysis purpose, used the secondary data from 1996-97 to 2015-16 which is further divided into four sub-periods, have been examined. The growth was examined by compound annual growth rate and contribution of area and productivity towards output growth by decomposition analysis. The study concludes that, the relative changes in area, production and productivity under soybean were not uniform as compared to the base year. Maximum relative change in the area was found to be 15.51% in the year 2004-05 and maximum decrease (-) 6.88% in the year 2014-15, whereas maximum increase in production and productivity were found to be 67.98 and 56.56%, respectively in the year 2003-04, and maximum decrease in the production and productivity were (-) 25.42 and (-) 27.68%, respectively in the year 2000-01. The overall compound growth rate of area and production of soybean were found to be positive and significant at the 1 per cent level of significance and productivity found positive but not significant during 1996-97 to 2015-16. In concern to the instability was found to be low in case of area under soybean as compared to production and productivity over the study period. The area effect was found to be 100.75%, whereas yield and interaction effect were (-) 0.41 and (-) 0.34% during study period. The degree of relationship between area and production of soybean crop was measured over the period is 0.83 which is significant at 1% level of significance.

Keyword: Soybean, compound growth rate, instability, decomposition analysis, variability.

INTRODUCTION

Soybean is the second important oilseed crops grown in different parts of India after groundnut. Soybean has emerged as golden bean of 21st century and it is largely used as oilseed. It is the single largest oilseed grown in the different agro-climatic conditions. Soybean is looked upon not merely as a means to supply food for humans and animals, but it also improves the soil fertility by fixing atmospheric nitrogen. Due to its unique qualities it is known with the name of miracle crop also. It has 18-20 per cent edible oil, 45 per cent protein with high level of amino acid.

Major soybean producing countries in the world are USA, Brazil, Argentina, China and India. Globally, area under soybean cultivation is around 121 million hectares and five major

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producing countries (USA, Brazil, Argentina, India and China) account for more than 85% of global soybean area and 88.5% of production. The record production of soybean was estimated during 2016-17 at 349 million tonnes, and projected to decline marginally to 347.6 million tonnes in the current year.

India has the fifth largest vegetable oil economy in the world. After cereals, oilseeds are the second largest agricultural commodity, accounting for the 14% of the gross cropped area in the country.

In India soybean cultivation has increased manifold as compared to any other oilseed crop and stands next only to groundnut, though commercial production of soybean began in 1971-72. Total area under soybean cultivation was 0.03 million hectare and production was 0.01 million tonnes (1970-71) in India and it increased to 10.10 million hectare and 12.21 million tonnes, respectively by the year 2011-12. Now, it increases 11.60 million hectares area but production decreases 8.57 million tonnes in 2015-16. In 1970-71, per hectare yield of soybean was 426 kg and it increased to the level of 1208.91 kg during 2011-12 and in 2015-16, per hectare yield 738 kg. Production and productivity decreases during 2015-16 due climate changes in the soybean covering States in India.

Today we have enlisted the top 10 largest soybean producing states in India (2018). Madhya Pradesh stands unique in the 1st position as the largest producing state of soybean in India. The state comprises of national value due to its production of Soybean to a large extent. It has been estimated that around 3.9 million tonnes of Soybeans are produced annually which is really significant and remarkable for the state growth. The 2nd largest soybean producing state is said to be Rajasthan following by Maharastra, Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, West Bengal, Tamil Nadu and Uttar Pradesh where the yielding power of this *Kharif* Crop has been cultivated in large extent in huge hectors of land that is basically a predominated soybean agricultural land.

MATERIALS AND METHODS

Present study was based on secondary data. For this utilizes the time series data of area, production and productivity of soybean for the period 1996-97 to 2015-16. The whole period i.e. from 1996-97 to 2015-16 is divided into four sub periods viz. I period (1996-97 to 2000-01), II period (2001-02 to 2005-06), III period (2006-07 to 2010-11), IV period (2011-12 to 2015-16), each period consist of five years. The data was collected from Ministry of Agriculture, Government of India.

Analytical Procedure

To examine the growth performance, instability, decomposition and degree of relationship in area, production and productivity of soybean. For the analytical procedure used the various statistical measures such as mean, correlation coefficient and coefficient of variation were worked out.

Compound Growth Rate Analysis

Growth rates are worked out to examine the tendency of variable to increase, decrease or remain stagnant over a period of time. It also indicates the magnitude of the rate of change in the variable under consideration per unit of time. For the present study, compound growth trend was used to estimate the growth in area, production and productivity of soybean crop. The algebraic form of the function as suggested by Kalita (2011) is given below:

$Y = a*bt$

The log form of the above exponential equation can be expressed as,

$\text{Log}(Y) = \text{Log}(a) + t\,\text{Log}(b)$

Now, CGR (%) can be expressed as

$\text{CGR}(\%) = [\text{Antilog}(b)-1]*100$

Where,

Y= variable for which growth rate is calculated, it may be area, production or productivity as per case

a = constant

b = regression coefficient of 'Y' on 't' and

t = time variable (rank was given to year concerned; ranking of the year was done in their ascending order as per case

Instability Analysis

The coefficient of variation was used as measure to study the variability in area, production and productivity of soybean. The coefficient of variation or index of instability was computed by using the following formula

$$CV = \frac{\text{Standard Deviation } (\sigma)}{\text{Mean } (X)} \times 100$$

Linear trend were fitted to the original data of area, production, productivity of soybean crop, for the period of 20 years. The trend coefficients were tested for their significance. Whenever the trend of series found to be significant; the variation around the trend rather than the

variation around mean was used as an index of instability. The formula suggested by Cuddy and Della (1978) was used to compute the degree of variation around the trend. That is Coefficient of variation was multiplied by the square root of the difference between the unity and adjusted coefficient of multiple determinations (R^2) in the cases where r2 was significant to obtain the Instability Index.

$II = CV\sqrt{(1-R^2)}$

Where,

II= instability Index

R^2 = Adjusted coefficient of multiple determination

Decomposition Analysis

The decomposition method of growth trend was first presented by Minhas and Vaidyanathan (1965). They had estimated the change in value of agricultural output by segregating the changes in three major factors: area, yield and the interactions.. They have used the additive method for working out the effects of the three factors. To estimate the effect of area, yield and their interaction on the overall growth performance of soybean production was estimated by using decomposition approach (Kalita, 2011). The algebraic form of equation is given below:

$$P = A_0(Y_n - Y_0) + Y_0(A_n - A_0) + \Delta A \Delta Y)$$

$$1 = \left[\frac{Y_0 \Delta A}{P}\right] + \left[\frac{A_0 \Delta Y}{P}\right] + \left[\frac{\Delta A \Delta Y}{P}\right]$$

Where,

P = Change in production

A_0 = Area in base year

A_n = Area in current year

Y_0 = Yield in base year

Y_n = Yield in current year

ΔA = Change in area ($A_n - A_0$)

ΔY = Change in yield ($Y_n - Y_0$)

RESULTS AND DISCUSSION

Trends in area, production and productivity of soybean

To determine the results in area, production and productivity of soybean in India, the index numbers were constructed by using 1996-97 as the base year. The indices of area, production and productivity are presented in Fig. 1. It is evident from the figure that, increasing trend

under the soybean was observed in area but fluctuation condition or not regular at the national level. The maximum change in area was observed in the year 2013-14 over the 20 years followed by in the year 1997-98, 1998-99 and 2013-14, respectively. The maximum declined in area was observed in the year 2015-16 over the last 20 years. In case of production maximum increasing trend was observed in 2012-13 followed by 2010-11, 2011-12 and 2013-14, respectively. Maximum declined in the year 2002-03. In case of productivity maximum increasing trend was observed in 2012-13 followed by 2010-11, 2007-08 and 2011-12, respectively. Maximum declined in the year 2015-16. The trend in the area, production and productivity were observed irregular.

These inter-annual variation in area and production of soybean crop is mainly depends on the rainfall pattern. Because of soybean is mainly grown during the kharif season under rain-fed condition in India. Soybean is predominantly grown as a rainfed crop covering the states of Madhya Pradesh, Maharashtra and Rajasthan; on vertisols and associated soils. Extreme variation in rainfall both in time and space acts as a major impediment in successful cultivation of soybean and realizing higher productivity coupled with level of technology adoption and other factors. It is one of the most resilient crops for the rainfed kharif season as despite aberrant weather conditions in past, the crop has maintained its performance. During the good monsoon year farmers are allocating more area under the crop, whereas it is reduced during the poor monsoon year and this affects overall production of soybean. Aberrant rainfall pattern and intermittent dry spells were observed in almost all major soybean growing states this season, which delayed sowing/ re-sowing of soybean that continue from 2nd week of June to mid-July. Rainfall was deficient in to mid- September period of major soybean growing regions, coinciding with the pod formation and grain filing stage of the crop. Therefore, the crop productivity and production is expected to decline marginally this year as compared to previous year.

Relative change in area, production and productivity of soybean

Fig.2 revealed that, relative increase or decrease in area under soybean was not uniform as compared to the base year. Maximum change in the area was found to be 15.51 per cent in the year 2004-05 followed by 10, 8.4, 8.08 and 8.06 per cent in 1997-98, 1998-99, 2013-14 and 2016-07, respectively. Maximum decreases in the area was (-) 6.88 in the year 2014-15 followed by (-) 4.11, (-) 3.75 and (-) 1.37 per cent in 1999-2000, 2002-03 and 2010-11, respectively.

In production also trend was not uniform. Maximum increase in production was found to be 67.98 per cent in the year 2003-04 followed by 27.79, 23.92 and 20.32 per cent in year 2010-11, 2007-08 and 2007-08, respectively. Maximum decrease in the production was (-) 25.42 per cent in the year 2000-01 followed by (-) 21.94, (-) 19.13 and (-) 17.39 and 2002-03, 2013-14 and 2015-16, respectively.

In productivity increasing trend was not regular. Maximum increase in productivity was found to be 56.56 per cent in the year 2003-04 followed by 29.49, 18.18 and 14.22 per cent in the year 2010-11, 2005-06 and 2001-02, respectively. Maximum decreases in productivity was found to be (-) 27.68 per cent in the year 2000-01 followed by (-) 25.20, (-) 23.89 and (-) 22.40 per cent in the year 2013-14, 2004-05 and 2015-16, respectively.

Compound growth rates of area, production and productivity of soybean

The compound growth rates of area, production and productivity of soybean divided in four sub- periods are shown in Table 1. The table shows that, the overall compound growth rate of area and production of soybean were found to be positive and significant at the 1 per cent level of significance and productivity found to be positive but not significant during 1996-97 to 2015-16. The positive growth in area, production and productivity of soybean can be seen in sub-periods II and III. During the sub-period I (1996-97 to 2000-01), productivity of soybean show, the negative growth rate i.e. (-) 3.09 per cent, while area and production under soybean shows positive (3.75 and 0.54%) growth rate and production found to be significant at 1 per cent level of significance. The highest growth in area, production and productivity were observed during the II sub-period (2001-02 to 2005-06) followed by sub-period III (2006-07 to 2010-11). In the sub-period II (2001-02 to 2005-06), growth of soybean in production and productivity were found to be positive (11.02 and 4.49 %) and significant at the 1 per cent level of significance and area significant at the 5 per cent level of significance. In the case of sub-period III (2006-07 to 2010-11), growth of area and productivity were found to be positive (3.83 and 2.58%) and significant at 5 per cent level of significance, while production also found positive (6.52%) and significant at 1 per cent level of significance. Growth rate of area was found to be positive (2.86%) and significant at 1 per cent level of significance, while growth of production and productivity found to be negative and non-significant during sub-period IV (2011-12 to 2015-16).

Instability analysis

For the estimation of inter annual fluctuation in area, production and productivity of soybean in India, the instability index was used. It is well known that fluctuation in area and

production are interrelated, if other factor remain constant than the increment in area gives the highest production but variation in productivity may be due to many reasons such as weather conditions, technological changes etc. Some exogenous factor like price also brings the variation in production of crop. The coefficient of variation and instability index in area, production and productivity of soybean for India is presented in Table 2.

The table shows that, as a whole the instability was found to be low in case of area under soybean as compared to production and productivity. The stability in area under soybean cultivation implies that soybean crop hold a significant portion in cropping pattern.

The instability in production and productivity was found to be highest in sub-period II (2001-02 to 2005-06). In the sub-period II, instability was found in productivity (16.78 per cent) followed by production (11.71 per cent) and area (4.92%). Whereas, lowest instability in area (2.95%), production (10.45%) and productivity (11.74%) were found in sub-period III (2006-07 to 2010-11). It was overall concluded that the variability in production is the compound result of fluctuation in productivity and area.

Decomposition analysis

To determine how contribution of area, productivity and their interaction are responsible for the overall growth of soybean production in India during the study period, decomposition analysis was carried out. The whole decomposition analysis was divided into four sub-periods. Growth in soybean production was decomposed into three factors viz. area effect, yield effect and interaction effect. Table 3 shows that, the contribution of area, productivity and their interaction to the change in production over the years.

Area effect

It is revealed from the Table 3 that the area under soybean production in India plays a major role in growth of soybean production due to area effect (100.75 per cent) during 1996-97 to 2015-16. Area effect was positive in the all sub-periods. Among four sub-periods, positive effect varies from 60.53 to 183.12 per cent. Highest area effect was found to be 183.12% in sub-period IV followed by 183.09% in sub-period II and minimum 60.53% in sub-period III.

Productivity effect

In growth decomposition, the major portion of output growth was explained by yield effect in most of the sub-periods I and III. In sub-period II and IV, the yield effect was found to be negative (-) 74.06% and (-) 69.37%, respectively, due to adverse climate condition and others factors during that period. It is quite obvious that the adverse climate affect and others factors

of soybean production which in turn reflects in yield. Overall yield effect was found to be negative (-) 0.41% during 1996-97 to 2015-16.

Interaction effect

The interaction effect means the effect of change in area and yield together towards increase in production of soybean. It is evident from the Table 3 that, the interaction effect was influencing soybean production in the India by (-) 0.34 per cent during 1996-97 to 2015-16, whereas maximum interaction effect found was (10.09%) in sub-period III followed by 2.78 in sub-period I. Interaction effect in case of sub-period II & IV were found to be negative i.e. (-) 9.03 and (-)13.74 %. The decomposition analysis was suggests that area was one of the important factors in overall development of soybean production followed by interaction effect. The result conform the findings of *Rao and Raju* (2005) who has studied the pattern of growth and magnitude of instability in area, production and yield of groundnut in Andhra Pradesh and conclude that the contribution of area has a higher effect on production of groundnut.

Correlation between area and production of soybean

The degree of relationship between area and production of soybean crop is measured by correlation test. It was observed that correlation coefficient (r) of area and production of soybean over the period i.e. 1996-97 to 2015-16 is 0.83 (Table 4), which is highly significant at one per cent level of significance. It is implying that the production of soybean crop is highly influenced by increment area.

Table 4: Relationship between Area and Production of Soybean

Criteria	Value of correlation	P (T<t) two- tail
Area Vs Production	0.83	0.01

**. Correlation is significant at the 0.01 level (2-tailed).

CONCLUSION

The above results indicated fact that the growth performance of area and production of soybean in India was positive and statistically significant but productivity was non-significant during the study period.

The area under soybean production in India was one of the important factors which influenced the overall growth of soybean production. The interaction of area and yield has a negative effect (-0.34) on the change in soybean production during this period.

The degree of relationship between area and production of soybean crop was found to be 83%. Therefore, it is necessary to increase the sustainable soybean production and to take up productivity enhancing measures in soybean crop.

The area, production and productivity of soybean registered positive and significant growth trend during the study period. The Instability Index suggested that there was highest inter-annual fluctuation in soybean production followed by variation in productivity and area during study period. Further the study conducted a decomposition analysis to determine the contribution of different components to the growth rate. The decomposition analysis suggested that area was one of the important factors in overall growth of soybean production followed by interaction effect. The productivity contribution to total soybean production was very low.

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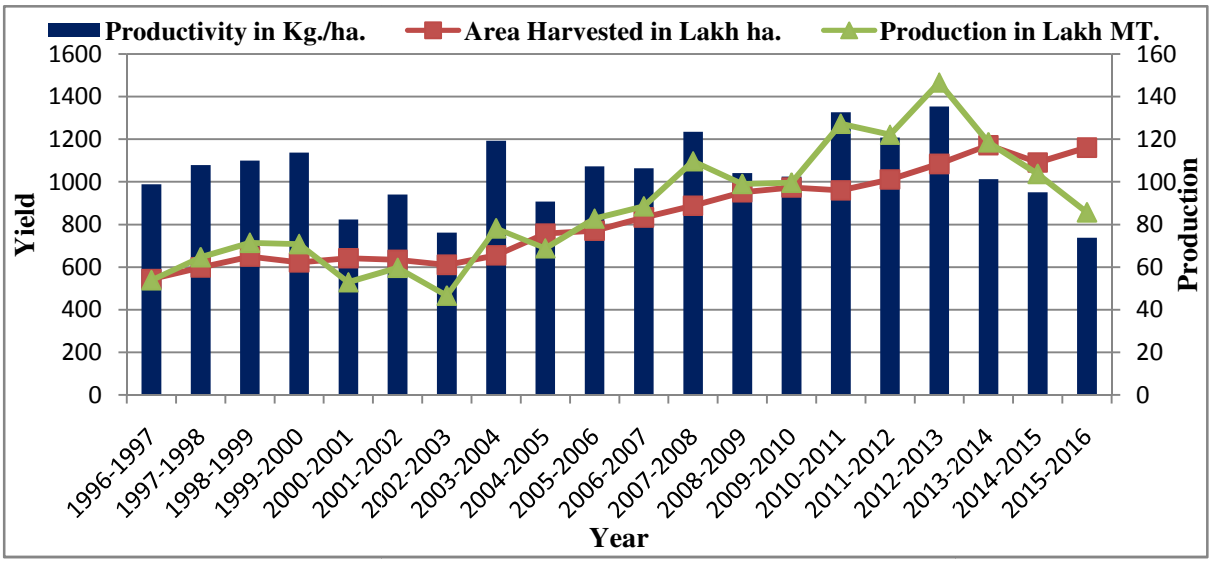
Fig.-1: Area Production and Productivity of Soybean in India Over the period from 1996-97 to 2015-16



Source: Ministry of Agriculture, Government of India

Fig.-2: Annual growth rate of Area Production and Productivity of Soybean in India Over the period from 1996-97 to 2015-16

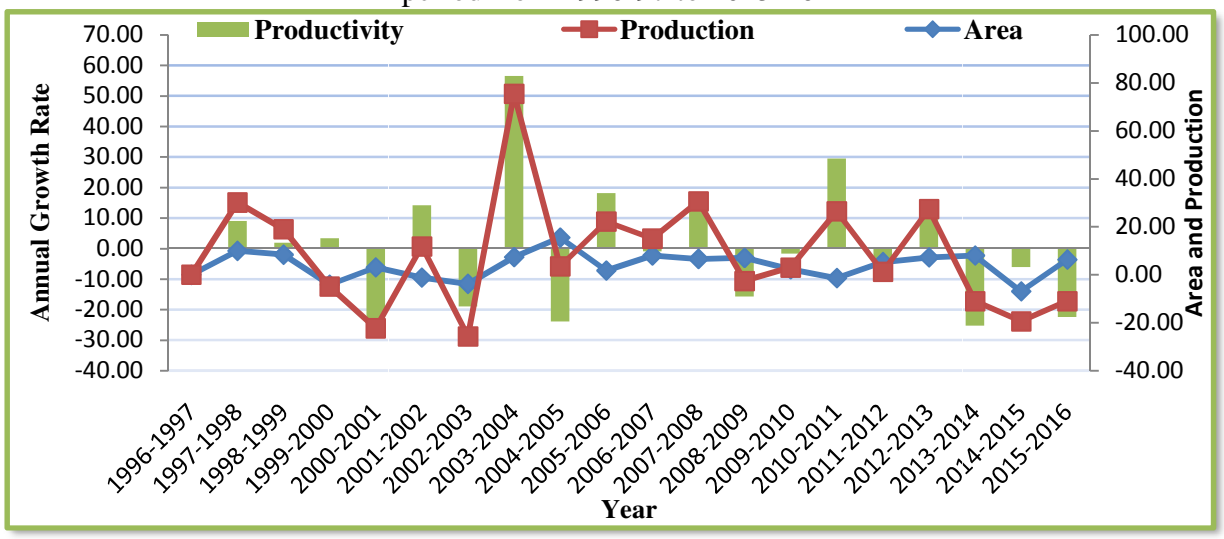


Table 1: Compound growth rates of area, production and productivity of soybean in India

Particulars	Period				Overall Period
	I (1996-97 to 2000-01)	II (2001-02to 2005-06)	III (2006-07 to 2010-11)	IV (2011-12 to 2015-16)	(1996-97 to 2015-16)
Area %	3.75	6.23*	3.83*	2.86*	4.23**
Production %	0.54**	11.02**	6.52**	-10.01	4.46**
Productivity %	-3.09	4.49**	2.58*	-12.50	0.22

*, ** denotes 5 per cent and 1 per cent level of significance.

Table 2: Instability in area, production and productivity of soybean in India (per cent)

Particulars	Period				Overall Period
	I (1996-97 to 2000-01)	II (2001-02 to 2005-06)	III (2006-07 to 2010-11)	IV (2011-12 to 2015-16)	(1996-97 to 2015-16)
Area	4.31	4.92	2.95	4.31	6.61
Production	15.55	11.71	10.45	14.33	21.47
Productivity	11.95	16.78	11.74	11.05	14.01

Table 3: Decomposition of output growth in soybean in India

Particulars	Period				Overall Period
	I (1996-97 to 2000-01)	II (2001-02 to 2005-06)	III (2006-07 to 2010-11)	IV (2011-12 to 2015-16)	(1996-97 to 2015-16)
Area effect (%)	74.65	183.09	60.53	183.12	100.75
Yield effect (%)	22.58	-74.06	29.38	-69.37	-0.41
Interaction effect (%)	2.78	-9.03	10.09	-13.74	-0.34