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RESEARCH ARTICLE :

Decomposition analysis and acreage response of soybean

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SUMMARY : In this study an attempt had been made to study the growth and instability of soybean in Amravati division. The study was based on secondary data on area, production and productivity of soybean, FHP and rainfall, collected from the various Government publications. The study revealed that compound growth rates for area, production and productivity of soybean was recorded positive. The growth rate for area, production and productivity was recorded high during period I. The co-efficient of variation and coppock's instability index with regards to area (1.08 and 0.62) productivity (2.00 and 1.62) were lowest in Akola and Amavati district, respectively, whereas production was recorded lowest co-efficient of variation and coppock's instability index in Akola district (0.86 and 0.48). At overall period, area effect, yield effect, and interaction effect do not show any influence on one another. The study also reveals that, the short run price elasticity were comparatively higher than the long run price elasticity in soybean, which indicated that the farmers were relatively market oriented in their decision in long run than in the short turn.

KEY WORDS :
Soybean,
Decomposition,
Growth rate,
Instability

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BACKGROUND AND OBJECTIVES

Agriculture in India continue to hold the important place in Indian economy, where about 50 per cent of population leaving in rural area out of which 60 per cent of total population depends on agriculture. Agriculture sector employees around 50 per cent of labour force on total of 163 million hectare out of 328.7 mha of land. It contributes about 40 per cent to the national income and its developments (Anonymous, 2012). Therefore, is indispensable to feed the increasing demand of vast population. In a developing economy like ours, growth leads to the building up of pressures on agriculture on account of the rising demand for agricultural products. This process is accelerated by the rapid growth of population accompanied by rising levels of income. Does supply of agricultural products respond to rising demand for them? This question becomes critical and assumes central importance and hence, calls for the efficient utilization of resources. The question regarding growth of supply has two aspects, both are equally important. The more widely known and understood aspect refers to the growth of agricultural products. This is a

major problem covering finding resources for agriculture to produce larger output and improving the institutional frame leading to a shift of the supply function. The second and equally important aspect deals with the shape of the supply curve or response of the supply of agricultural products to changing level of prices.

The supply response of crop or acreage response of agricultural crop is one of the important procedure tools predicting crop production. Agriculture is the most important sector in the economy of nation. In India during the last two decades increase in population has been more pronounced than increase in agricultural production, creating a lag in the availability and requirement of food crop. Thus, to feed and cloth the teaming millions of India, the pace of agricultural production has been increased for proper planning and policy formulating. It is a matter of paramount importance of study the behaviour of farmer's attitude towards area allocation to different crops. Thus, the function of functional changes in per acre production of its agricultural crop with respect to the change of its market price is known as the crop acreage response.

RESOURCES AND METHODS

Selection of crop :

For the present study, major crop of Amravati division *i.e.*, soybean, was selected purposively.

Selection of period :

For the growth rate and decomposition analysis, the period was divided into breakup of 10 years and overall as shown below:

Period I - 1982-83 to 1991-92,
Period II - 1992-93 to 2001-2002,
Period III - 2002-2003 to 2011-12,
Over all period - 1982-83 to 2011-12.

Nature and source of data :

Data used for present study were collected from various Governments and published source. The time series secondary data on area, production and productivity of soybean were obtained from various Governments published sources.

Analysis technique employed for analysing the data:

The present study was based on time series secondary data of soybean in Amravati division.

Growth rate analysis :

The compound growth rate of area, production and yield for major crop was estimated for two sub periods.

The first period was 1982-83 to 1992-93 and second 1992-93 to 2013-14.

$$Y = ab^t$$

$$\text{Log } Y = \log a + t \log b$$

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

where,

CGR = Compound growth rate
t = time period in year
y = area/ production / productivity
a and b = Regression parameters

Instability analysis :

To measure the instability in area, production and productivity, an index of instability was used as a measure of variability.

The co-efficient of variation (cv) was calculated by the formula :

$$CV(\%) = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

The simple co-efficient of variation (CV) often contains the trend component and thus, overestimates the level of instability in time series data characterized by long-term trends. To overcome this problems, this study was used the instability index (II) given by Coppock's instability index of variation.

Coppock's instability index is a close approximation of the average year to year per cent variation adjusted for trend.

The algebraic form of equation is :

$$CII = [(\text{Anti log}\sqrt{V \log} - 1 \times 100)]$$

$$V \log = \sum \frac{[\log \frac{(X_{t+1})}{X_t} - m]^2}{N - 1}$$

where,

x_t = Area/production/productivity in the year 't'
N = Number of year
m = Arithmatic mean of difference
Vlog = Logarithmic variation of the series

Decomposition analysis :

To measure the relative contribution of area and yield to the total output change for the cotton, Minhas (1964), the decomposition analysis model as given below was used. The method state that if A_0, P_0 and Y_0,

respectively area, production and productivity in base year and A_n, P_n and Y_n are values of the respective variable in n^{th} year, then :

$$Po = Ao \times Yo \text{ and}$$
$$Pn = A_n \times Y_n \quad (1)$$

where,

Ao and A_n represent the area and Yo and Y_n represents the yield in the base year and n^{th} year, respectively.

$$P_n - Po = a\,P,$$
$$A_n - Ao = a\,P$$
$$Y_n - Yo = a\,Y \quad (2)$$

From equation (1) and (2) we can write

$$Po + a\,P = (Ao + a\,A)\,(Yo + a\,Y)$$

hence,

$$P = \frac{A_0 \Delta Y}{\Delta P} \times 100 + \frac{Y_0 \Delta A}{\Delta P} \times 100 + \frac{\Delta Y \Delta A}{\Delta P} \times 100$$

Production = Yield effect + area effect + interaction effect

Thus, the total change in production can be decomposed into three components *viz.*, yield effect, area effect and the interaction effect due to change in yield and area.

Acreage response analysis :

The model which generally used in supply response analysis based on time series data will be adaptive expectations (or distributed lag) model. In the present study the Nerlovian lagged adjustment model (1958) was used. The acreage response means the change in acreage with the unit change in the variables affecting on during the period of study.

The model used in the present study is as follows.

$$At = a + b_1 A_{t-1} + b_2 FHP_{t-1} + b_3 Y_{t-1} + b_4 W_t + b_5 Y_R + b_6 P_R$$

where,

a = Area

A_t = Area under crop at time ,t' ('00' ha)

A_{t-1} = One year lagged area under the crop (,00' ha)

FHP_{t-1} = Lagged year farm harvest price of the crop (kg/ha)

Y_{t-1} = One year lagged yield

W_t = Weather variable as three month average pre sowing rainfall (mm)

Y_R = Yield risk (co-efficient of variation of last three years)

P_R = Price risk (co-efficient of variation of last three years)

b_1..... b_6 = Parameters of multiple linear regression

Short run and long run elasticity :

The elasticity of variables show that the influence of unit change in variable on acreage decisions of crops. In the present study, variable elasticity were estimated for short run as well as for long run period.

Moreover, the short run and long run elasticity have been estimated as :

$$\text{Short run elasticity (SRE)} = \text{Regression co-efficient of price} \times \frac{\text{Mean of price}}{\text{Mean of area}}$$

$$\text{Long run elasticity (LRE)} = \frac{\text{SRE}}{\text{Co-efficient of area adjustment (r)}}$$

where,

r = 1 – (co-efficient of lagged area)

OBSERVATIONS AND ANALYSIS

The results obtained from the present investigation have been presented in the following sub heads:

Growth performance of soybean :

The growth performance of soybean pertaining to three period and overall is presented in the Table 1, which revealed due to introduction of soybean in the region during period I, the growth rate of area, production and productivity was recorded positive in all districts. The highest increasing trend in area was recorded in Akola district *i.e.*, 68.00 per cent and highest production was recorded in Yavatmal district *i.e.*, 79.01 per cent per annum and highest productivity was recorded in Buldhana district *i.e.*, 30.77 per cent per annum. The lowest increase in area was recorded in Buldhana district *i.e.*, 24.57 per cent per annum. Statistically all the districts and as a whole Amravati division, in area Yavatmal showed significance at 5 per cent level and Amravati district showed significance at 10 per cent level and Akola and Buldhana showed statistically in significant. In the productivity Buldhana and Yavatmal and whole Amravati division showed the significance statistically at 1 per cent level. The result revealed that during period II picture has been drastically changed, the growth rate has been increased in area, production and productivity. In Yavatmal district it has been found significant in area with 10 per cent significance and production with 1 per cent level of significance. Akola district also showed

significance of 10 per cent per annum in area and production in this period whereas a whole Amravati Division showed significance of compound growth rate only in area at 1 per cent level of significance and production at 10 per cent level of significance (Ghosh, 2002).

The result in the period III, revealed that there was positive growth rate in the area, production *i.e.*, 0.89 per cent, 19.74 per cent in Akola district, 4.41 per cent, 1.22 per cent in Buldhana district and 6.09 per cent and 1.07 per cent per annum in Yavatmal district. In Amravati district area, production and yield has been decreasing in a very decreasing rate. In the Amravati division as a whole, in this period growth rate of production and yield was registered negative with area increasing in a decreasing rate. Statistically compound growth rate of area of Amravati district was significant in 1 per cent level, Akola showed significancy in area and production at 0.89 per cent and 19.74 per cent with 1 per cent significancy level, respectively. The growth rate was also worked for the overall period (pooled period of 30 years) for soybean where almost all found to be positive.

Statistically compound growth rate in area and production, all districts showed significance at 10 per cent level of significance and productivity was registered positive for all districts except. Akola but statistically insignificant, whole Amravati division showed significance in area, production and productivity with 10 per cent level of significance. In whole Amravati division Yavatmal district showed highest increase in area, production and

Table 1 : District wise compound growth rates for soybean

Particulars		Amravati	Akola	Buldhana	Yavatmal	Amravati division
Period I	Area	35.55*	68.00	24.57	48.53**	44.16*
	Production	64.53***	76.59*	42.52	79.01*	65.67*
	Yield	21.28	26.21	30.77***	28.87***	26.78***
Period II	Area	13.09***	35.16*	47.11***	24.89*	30.06***
	Production	14.82*	41.04*	46.46**	27.73***	32.51*
	Yield	4.27	3.42	-0.36	1.29	-9.34
Period III	Area	0.82***	0.89***	4.41**	6.09**	3.05**
	Production	-0.97	19.74***	1.22	1.07	-5.75***
	Yield	0.97	-3.16	-1.12	-0.25	-1.37
Overall period	Area	10.51*	0.20*	0.38*	24.35*	8.86*
	Production	9.51*	17.76*	38.36*	22.65*	22.07*
	Yield	3.74*	-0.15	2.99***	1.93	-2.20*

Note: *, ** and *** indicate significance of values at P=0.01, 0.05 and 0.1, respectively

Table 2 : District wise instability indices of soybean

Name of district	Particulars	Period I		Period II		Period III		Overall	
		CV	CII	CV	CII	CV	CII	CV	CII
Amravati	Area	2.21	0.36	1.93	1.34	28.56	19.81	10.9	7.17
	Production	1.49	0.74	1.89	1.19	3.69	3.67	2.35	1.86
	Yield	2.00	1.62	3.27	2.95	10.80	10.31	5.35	4.96
Akola	Area	1.37	0.72	1.08	0.62	28.58	19.81	10.34	7.05
	Production	1.13	0.72	0.86	0.48	1.44	1.09	1.14	0.76
	Yield	4.68	4.44	5.42	4.61	2.28	2.25	4.12	3.76
Buldhana	Area	1.64	1.34	1.38	1.08	5.32	4.27	2.78	2.23
	Production	2.12	2.01	1.23	0.97	9.56	9.04	4.30	4.00
	Yield	2.19	1.23	4.65	4.64	5.13	5.03	3.99	3.63
Yavatmal	Area	1.21	0.76	1.55	0.91	4.44	3.39	2.4	1.68
	Production	1.11	0.43	1.20	0.82	8.72	8.35	3.67	3.2
	Yield	2.33	1.28	3.33	3.30	3.94	3.74	3.23	2.77
Amravati division	Area	1.60	0.79	1.48	0.98	16.72	11.82	6.60	4.53
	Production	1.46	0.97	1.29	0.86	5.85	5.54	2.86	2.45
	Yield	2.8	2.14	4.16	3.87	5.53	5.28	4.17	3.78

productivity in Amravati district in soybean.

Instability of soybean :

The Table 2 revealed that during period I, co-efficient of variation for the area was less as compared to production but more as compared to yield. In Akola co-efficient of variation for the area was 1.37 per cent per annum whereas co-efficient of variation for the yield was 4.68 per cent per annum. Highest co-efficient of variation for area was found in Amravati district *i.e.*, 2.21 per cent per annum. For the production Buldhana district has got the highest co-efficient of variation *i.e.*, 2.12 per cent per annum and for yield Akola district has recorded highest co-efficient of variation *i.e.*, 4.68 per cent per annum. As a whole Amravati Division has got co-efficient of variation of 1.60 per cent, 1.46 per cent and 2.8 per cent per annum, respectively for the area, production and productivity (Pandy *et al.*, 2005).

In the same way CII was found highest for area in the Buldhana district *i.e.*, 1.34 per cent per annum. In the production Buldhana district recorded highest as 2.01 and yield Akola district recorded highest as 4.44 per cent per annum, respectively. On the other hand it showed CII in the range of 5 to 20 per cent per annum which indicate inconsistent in the area, production and productivity of soybean in all the districts of Amravati division. On the other hand high production instability than area and yield instability was estimated for all the districts of western Vidarbha zone as well as zone as a whole contributed towards production fluctuation in the period I.

Table3 : Per cent contribution of area, yield and their interaction for increasing production of soybean

Period	Particulars	Amravati	Akola	Buldhana	Yavatmal	Amravati division
Period I	Area effect	50.86	47.26	71.99	135.13	76.31
	Yield effect	10.24	1.13	0.42	-22.96	-2.79
	Interaction effect	38.88	51.6	27.57	12.17	32.55
Period II	Area effect	28.37	69.03	57.16	115.61	67.54
	Yield effect	44.80	5.26	244.82	-4.79	72.52
	Interaction effect	26.82	25.69	-36.28	-10.81	1.35
Period III	Area effect	-92.41	161.04	177.35	38.97	71.23
	Yield effect	174.38	-10.79	-3.29	3.1	40.85
	Interaction effect	18.05	-50.25	-14.06	57.16	2.75
Overall period	Area effect	95.20	39.14	91.33	55.86	70.38
	Yield effect	1.20	0.25	0.19	0.5	0.53
	Interaction effect	3.52	60.59	8.46	43.63	29.05

Table 4 : Estimated co-efficient for acreage response function of soybean

Particulars	Variables	Co-efficients				
		Amravati	Akola	Buldhana	Yavatmal	Amravati division
	Intercepts	181.65	209.51	481.98	814.53	239.29
One year lagged area	A_{t-1}	0.10	4.62	0.79	0.86*	0.84
One year lagged farm harvest price	FHP_{t-1}	0.53	0.11	0.58***	0.44	0.18
One year lagged yield	Y_{t-1}	1.21	0.61***	-0.26	-0.03	0.54
Annual rainfall	w_t	0.93***	0.83***	-1.03	-1.38	0.32
Yield risk	Y_r	33.50	11.03***	-6.45	0.07	0.12
Price risk	P_r	0.25	0.01	0.29	0.26	8.71
Co-efficient of determination	R^2	0.91	0.94	0.90	0.97	0.83

Note : *, ** and *** indicate significance of values at P=0.01, 0.05 and 0.1, respectively

Table 5 : District wise price elasticity of soybean

Sr. No	Name of districts	SRE	LRE
1.	Amravati	0.79	0.42
2.	Akola	0.56	0.84
3.	Buldhana	0.34	0.67
4.	Yavatmal	-0.42	-0.66

The instability in the area was found to be increasing in period III. Similarly instability in production and yield has been recorded increasing in all the districts and as a whole Amravati division except Akola district which decreased from co-efficient of variation 4.68 per cent to 2.28 per cent per annum in yield. Similarly CII has been recorded increasing in almost all the districts and Amravati division as a whole for area, yield and production. As a whole in this period least CV and CII were obtained in the whole western Vidarbha *i.e.,* 1.44 per cent and 1.09 per cent per annum, respectively and in the Akola district. During the overall period *i.e.,* 30 years as a whole, Buldhana district recorded lowest degree of instability in area *i.e.,* CV 2.78 per cent and CII 2.23 per cent per annum. Similarly in production Akola district recorded with lowest which showed CV 1.14 and yield Yavatmal district recorded with lowest which showed CV 3.23 per cent. Whereas Akola recorded highest instability in area *i.e.,* CV 10.90 per cent per annum but Buldhana showed in CII *i.e.,* 2.23 per cent per annum. Akola in the production as well *i.e.,* 1.14 per cent and CII 0.76 per cent per annum and in the yield Akola again shows highest CV *i.e.,* 30.9 per cent per annum but through CII Amravati district came highest by 17.68 per cent per annum in the 30 years overall period. This all indicated least consistency in terms of area, production and productivity during overall period of 30 years.

Decomposition analysis of soybean :

The decomposition of soybean production in area, yield and interaction effect is presented in Table 3 and results demonstrate that per cent contribution of area, yield and their interaction for increasing production of soybean in Western Vidarbha (*i.e.,* Amravati division) and overall also.

During period I, the result clearly indicate that the area effect was mostly influenced the production of soybean in Amravati division with yield effect -2.79 per cent and interaction effect 32.55 per cent. Interaction effect was positive for all the districts with highest interaction effect of 51.6 per cent in Akola district. Highest yield effect was recorded in Amravati *i.e.,* 10.24 per cent and the Yavatmal district recorded highest area effect *i.e.,* 135.13 per cent. In all the districts positive yield effect was recorded except Yavatmal district which showed negative yield effect *i.e.,* -22.96 per cent. Amravati district showed all the effect nearer to be proportional and in other area effect has played a driving force in the differential production of soybean in Amravati division during I period (Kalamkar *et al*., 2002).

In the contrary during period II, it was noticed that yield effect has got domination over the area effect only in Amravati and Buldhana district. In Amravati division as a whole area effect was found only 67.54 per cent whereas yield effect was 72.52 per cent and interaction effect was 1.35 per cent. Lowest area effect was found in the Amravati district *i.e.,* 28.37 per cent and highest yield effect was found in Buldhana district with 244.82 per cent. In all the districts yield effect was positive except Yavatmal district which showed negative yield effect *i.e.,* -4.79 per cent. It is also recorded in this period that interaction effect was positive in Amravati and Akola districts and in Amravati division except Buldhana and Yavatmal district.

Period III also recorded as like the period II but area effect has been shown increased somehow. In whole Amravati division area effect, yield effect and interaction effect was recorded 71.23 per cent, 40.85 per cent and 2.75 per cent, respectively. Highest area effect was shown in Buldhana district *i.e.,* 177.35 and negative interaction effect was also shown in this district and in Akola district *i.e.,* -14.06 per cent and -50.25 per cent, respectively. Highest yield effect and lowest area effect were recorded in Amravati district *i.e.,* 174.38 per cent and -92.41 per cent, respectively. So we can conclude that in this period area, yield and interaction effect were highly fluctuating. During overall period, it is observed that yield effect was not increased with respect to area effect. Positive area effect was recorded in all four district with highest area effect was recorded in Amravati district *i.e.,* 95.20 per cent. Similarly positive yield and interaction effect was recorded with highest yield effect in Amravati district *i.e.,* 1.20 per cent and interaction effect in Akola district *i.e.,* 60.59 per cent, respectively.

Acreage response of soybean :

The co-efficient of farm harvest price were very less *i.e.,* 0.53, 0.11, 0.58 and 0.44 in Amravati, Akola, Buldhana and Yavatmal districts, respectively (Table 4). It was significant at 1 per cent level of significance only in Buldhana district which implies positive relationship between the variations in the hectare age of soybean and farm harvest price. It implied that prices had not shown any impact in the increase on area of soybean in the study period. One year lagged yield was also included in the function but the co-efficient turned out to be small

and negative in Buldhana and Yavatmal district and significant in Akola district at 1 per cent level of significance which implies that one year lagged yield had vey less impact to area allocation of soybean in all the districts of western Vidarbha zone of Maharashtra (Engale and Bhise, 2009).

The annual rainfall was employed as a proxy for combating the weather influence on the pigeonpea hectare age allocation decisions. The co-efficient of annual rainfall variable showed positive relationship for Buldhana, Yavatmal, and Amravati districts and negative relations to Akola district and statistically insignificant in all the districts which showed annual rainfall favourably didn't influence the area allocation decision of the farmers and in Akola district it produced the negative relationships. The yield risk variable was incorporated in the model to gauge the impact of risk over the variation in the hectare age under soybean (Shende *et al.*, 2011).

The co-efficient of variable had a positive except Buldhana district. Statistically Akola showed significance at 1 per cent level of significance which shows farmers in Amravati, Akola and Yavatmal are relatively better risk bearers except than Buldhana. It was also recorded that regression co-efficient of price risk variable or factors were positive in all the districts. In all these districts cases, it indicate that farmers were relatively better risk bearers but statistically non-significant. The value of $R^{2,}$ the co-efficient of multiple determinations ranged from 0.91 to 0.83 for all the districts of Amravati division. 0.91 was found in Amravati districts and it was 0.94, 0.90, and 0.97 found in Akola, Buldhana and Yavatmal district, respectively which indicates that variables included in the model explained most of the variations in area under soybean in the study period.

Short run and long run elasticity :

The price elasticity showed the influence of unit change in price on acreage allocation of the crop. In the present study price elasticity were estimated for short run as well as for long run period.

District wise price elasticity of soybean :

The short run price elasticity for different districts were 0.79, 0.56, 0.34 and -0.42 for Amravati, Akola, Buldhana and Yavatmal districts, respectively. The highest short run price elasticity was found in the Amravati district and negative price elasticity was found in the Yavatmal district *i.e.*, -0.42 which is fairly highest and is called for further investigation.

The long run elasticity for Amravati, Akola, Buldhana and Yavatmal districts were 0.42, 0.84, 0.67 and -0.66, respectively. Yavatmal districts again revealed negative price responsiveness for long run as well. It is also recorded from the Table 5 that long run price elasticity were comparatively higher than the short run price elasticity indicated that the farmers were relatively market oriented in their decisions in the long run than in the short run in respect to the soybean in the western Vidarbha region of the Maharashtra (Alogh, 2004).

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