



Research Article

GROWTH AND INSTABILITY OF AREA, PRODUCTION AND PRODUCTIVITY OF SOYBEAN IN MAJOR STATES OF INDIA

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Abstract: Soybean is an oilseed crop with inadvertent importance. It is a good source of protein both for human beings and livestock. The production and demand for soybean have been many traits increased in India during the last decade resolving in its wider adoption among farmers in Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Gujarat. The secondary data on area, production and yield of soybean crop in seven major producing states of India were collected for period from 1990-91 to 2019-20. The data were analyzed using compound growth rate, coefficient of variation and Cuddy Della Valle index. The investigation revealed that, among the major soybean growing states, Gujarat recorded the highest increase in soybean area and production about 10.07 and 10.75 per cent during 1990-91 to 2019-20, respectively. At all India level shown significantly positive growth in soybean area (4.60%), production (5.10%) and yield (0.46%) during overall period. Gujarat, Karnataka and Rajasthan had recorded having high instability in production during the overall study period. This study suggests that the very low productivity of soybean in India compared to the world indicates that there exists a vast untapped yield potential, which can be achieved by research and extension efforts in India.

Keywords: Soybean, Growth Rate, Instability, Cuddy Della Valle index

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Introduction

Soybean (*Glycine max* L.) is one of the most important oilseeds crops grown in India which accounts for about 30 per cent area and around 16 per cent of total oilseeds production in India. Soybean is the fastest growing crop in India which replaced crops like maize, cotton and pulses. Huge fluctuations in prices of farm produce are observed during the past few years. The global area under soybean was 1654.57 lakh hectares leading to a production of 3149.55 lakh tonnes with Brazil, the USA, and Argentina alone contributing 84 per cent of global output during 2019-20. The major countries based on area under soybean cultivation were Brazil, the USA, Argentina, India, China, Paraguay, and Canada [1]. Soybean was cultivated in 107.61 lakh hectares in India with a production of 93.06 lakh tonnes and productivity of 865 kg/ha during 2019-20. The major soybean growing states in the country were Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh and Gujarat during 2019-20. Madhya Pradesh was the leading state in terms of area and production of soybean while, Maharashtra was the leading state in terms of productivity of soybean [2].

Material and Methods

The study had used secondary data to measure growth and instability of major seven states i.e., Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, Karnataka, Andhra Pradesh and Chhattisgarh. The analysis of growth and instability in area, production and productivity was carried out from the year 1990-91 to 2019-20, which in turn, split into four periods viz., Period- I (1990-91 to 1999-2000), Period- II (2000-01 to 2009-10) and Period-III (2010-11 to 2019-20) and overall Period-IV (1990-91 to 2019-20). The compound growth rates (CGRs), coefficient of variation (CV) and Cuddy-Della Valle index (CDV) of area, production and productivity of soybean were computed for the major states of India and India as a whole.

Results and Discussion

Temporal changes in area, production and productivity of soybean

The growth rate results and its discussion has been proceeded state wise for each period. Besides, at all India level the soybean area, production and productivity discussed thoroughly and results are presented in [Table-1]. During 1990s, Madhya Pradesh occupied the highest mean area among all the states in India about 3600.52 thousand hectares which in period-I, steadily increased to 5707.73 thousand hectares in period-III. Madhya Pradesh achieved the highest mean production about 3540.46 thousand tonnes, followed by Maharashtra and Rajasthan in Period-I, which showed an increasing trend in subsequent periods. In case of soybean production in Period-I, Andhra Pradesh registered significantly the highest growth rate of 49.71 per cent per annum followed by Maharashtra (26.64%) and Rajasthan (19.27%). At all India level, the soybean production was annually increased significantly at the rate of 13.05 per cent, during period-I. During Period-I, the growth rate of productivity of soybean was recorded the highest in Karnataka about 6.99 per cent per annum followed by Maharashtra (5.21%) and Rajasthan (2.63%). At all India level, the soybean yield was increased at the rate of 2.56 per cent per annum in Period-I. In Period-II, significantly the highest increase in area under soybean was reported in Gujarat (38.17%). Besides, Chhattisgarh (31.13%), Andhra Pradesh (29.39%), Maharashtra (20.38%) and Karnataka (13.29%) witnessed high growth in Period-II. While, Rajasthan (4.16%) and Madhya Pradesh (2.34%) shown the low, but significant positive growth in area of soybean in Period-II. At all India level in Period-II, the growth rate in area was increased significantly at the rate of 5.73 per cent per annum. In case of soybean production in Period-II, Chhattisgarh registered significantly the highest growth rate of 37.06 per cent per annum, followed by Gujarat (33.17%), Andhra Pradesh (22.33%), Karnataka (12.37%) and Maharashtra (10.18%).

Table-1 Period wise growth rates of soybean area, production and productivity of major states in India

Periods	State/ Item	Madhya Pradesh			Maharashtra		
		A	P	Y	A	P	Y
Period-I (1990-91 to 1999-00)	Mean	3600.52	3540.46	972.15	629.27	747.28	1110.49
	CGR%	8.23***	10.34***	1.95***	20.38***	26.64***	5.21***
	SE	0.08	0.12	0.09	0.11	0.23	0.17
Period-II (2000-01 to 2009-10)	Mean	4632.33	4850.04	967.85	2080.74	2573.72	1125.87
	CGR%	2.34***	8.65***	5.47***	13.67***	10.18***	-3.37***
	SE	0.05	0.14	0.13	0.1	0.23	0.21
Period-III (2010-11 to 2019-20)	Mean	5707.73	6078.17	1071.48	3555.4	3998.37	1143.94
	CGR%	-0.41***	-2.30***	-1.89***	4.21***	0.47**	-3.59**
	SE	0.07	0.15	0.19	0.05	0.32	0.34
Overall Period (1990-91 to 2019-20)	Mean	4646.86	4715.07	1003.83	2088.47	2338.13	1126.77
	CGR%	2.55***	3.15***	0.59***	10.04***	9.99**	-0.05***
	SE	0.13	0.21	0.17	0.26	0.41	0.26

Periods	State/ Item	Rajasthan			Karnataka		
		A	P	Y	A	P	Y
Period-I (1990-91 to 1999-00)	Mean	389.43	441.81	1101.14	47.7	35.09	703.86
	CGR%	16.22***	19.27***	2.63***	11.18***	18.95***	6.99***
	SE	0.2	0.27	0.16	0.15	0.31	0.3
Period-II (2000-01 to 2009-10)	Mean	669.36	806.74	1095.25	111.96	81.13	687.63
	CGR%	4.16***	9.33**	5.10***	13.29***	12.37***	-3.83***
	SE	0.16	0.36	0.32	0.27	0.22	0.24
Period-III (2010-11 to 2019-20)	Mean	999.8	1079.7	1111.39	242.59	222.19	921.17
	CGR%	1.73***	-5.36***	-6.97**	7.04***	7.81***	0.72***
	SE	0.14	0.24	0.3	0.12	0.22	0.26
Overall Period (1990-91 to 2019-20)	Mean	686.2	754.01	1102.59	134.08	109.86	770.89
	CGR%	5.50***	5.37**	-0.12***	8.82***	10.41***	1.46***
	SE	0.24	0.4	0.29	0.19	0.29	0.29

Periods	State/ Item	Andhra Pradesh			Gujarat		
		A	P	Y	A	P	Y
Period-I (1990-91 to 1999-00)	Mean	7.34	7.04	1024.81	13.19	9.85	766.64
	CGR%	53.84**	49.71**	-2.69***	-13.12**	-13.81***	-0.79***
	SE	0.62	0.53	0.15	0.31	0.2	0.19
Period-II (2000-01 to 2009-10)	Mean	80.46	134.76	1379.69	39.16	31.71	680.41
	CGR%	29.39***	22.33**	2.27***	38.17***	33.17***	-2.66***
	SE	0.35	0.5	0.31	39.16	31.71	680.41
Period-III (2010-11 to 2019-20)	Mean	190.25	274.93	1503.09	87.23	79.62	885.96
	CGR%	2.36***	1.71***	-0.69***	11.47***	15.90***	3.97***
	SE	0.3	0.2	0.23	0.31	0.35	0.22
Overall Period (1990-91 to 2019-20)	Mean	92.68	132.13	1302.53	46.53	38.3	777.67
	CGR%	21.61 ^{NS}	23.61 ^{NS}	1.64***	10.07*	10.74*	0.61***
	SE	0.78	0.79	0.24	0.62	0.62	0.24

Periods	Item	Chhattisgarh			All India		
		A	P	Y	A	P	Y
Period-I (1990-91 to 1999-00)	Mean	5.51	4.78	895.81	4740.02	4831.33	1000.52
	CGR%	39.63 ^{NS}	36.71 ^{NS}	-2.09***	10.22***	13.05***	2.56***
	SE	0.84	0.86	0.14	0.08	0.11	0.09
Period-II (2000-01 to 2009-10)	Mean	45.85	55.98	880.16	7715.45	7855.5	1006.25
	CGR%	31.13***	37.06***	6.46***	5.73***	8.92***	3.02***
	SE	0.17	0.28	0.18	0.04	0.13	0.13
Period-III (2010-11 to 2019-20)	Mean	101.09	83.42	831.73	10961.87	11900.31	1093.67
	CGR%	-2.65***	-6.46***	-3.91***	1.53***	-1.14***	-2.63***
	SE	0.11	0.24	0.3	0.06	0.16	0.18
Overall Period (1990-91 to 2019-20)	Mean	50.82	44.14	869.23	7805.78	8195.71	1033.48
	CGR%	18.54 ^{NS}	18.00 ^{NS}	-0.46***	4.60***	5.10***	0.46***
	SE	0.73	0.8	0.24	0.13	0.22	0.15

Note: 1. *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively.

2. CGR = Compound Growth Rate, SE = Standard Error and NS= Non-Significant, 3. A = Area (000'ha), P = Production (000' tonnes) and Y = Yield (kg/ha)

Besides, Rajasthan and Madhya Pradesh shown low growth rate of 9.33 and 8.65 per cent per annum in Period-II, respectively. At all India level, soybean production was annually increased at a significant rate of 8.92 per cent.

During Period II, the growth rate of productivity of soybean was reported the highest in Chhattisgarh at the rate of 6.46 per cent per annum, followed by Madhya Pradesh (5.47%) and Rajasthan (5.10%). At all India level, the soybean yield was increased at the rate of 3.02 per cent per annum in Period-II.

In Period-III, Gujarat obtained significantly the highest growth rate of soybean area about 11.47 per cent per annum, followed by Karnataka (7.04%), Maharashtra

(4.21%), Andhra Pradesh (2.36%) and Rajasthan (1.73%). Whereas, Madhya Pradesh and Chhattisgarh registered negative growth in area of soybean in Period-III. At all India level, growth rate in area was increased at the rate of 1.53 per cent per annum during Period-III. Sajesh *et al.* (2014) [3] noted similar results for soybean area in Maharashtra during 2001-2010.

In Period-III, significantly the highest increase in soybean production was reported in Gujarat (15.90%) followed by Karnataka (7.81%), Andhra Pradesh (1.71%) and Maharashtra (0.47%). While, Chhattisgarh, Rajasthan and Madhya Pradesh registered negative growth in production of soybean in period-III.

Table-2 *Instability analysis of soybean area, production and productivity*

SrNo	Instability in sugarcane (APY)	Period-I		Period-II		Period-III		Over All Period	
		(1990-91 to 1999-20)		(2000-01 to 2009-10)		(2010-11 to 2019-20)		(1990-91 to 2019-20)	
		CV(%)	CDV(%)	CV(%)	CDV(%)	CV(%)	CDV(%)	CV(%)	CDV(%)
1		Madhya Pradesh							
	Area	23.24	6.19	8.87	5.5	7.02	7.35	22.42	9.81
	Production	29.63	10.15	26.16	10.5	15.67	14.92	31.25	19.43
	Productivity	10.2	9.03	19.15	11.93	17.54	17.73	16.38	15.72
2		Maharashtra							
	Area	50.88	8.86	36.56	7.43	12.64	3.94	63.35	10.48
	Production	65.23	22.86	37.26	25.42	24.91	26.35	66.45	29.86
	Productivity	21.21	16.19	21.03	20.34	28.54	27.3	23.12	23.53
3		Rajasthan							
	Area	41.88	16.59	18.15	14.17	14.16	14.15	42.09	15.59
	Production	51.23	24.47	30.23	22.66	23.87	20.37	46.82	30.2
	Productivity	15.85	14.85	27.49	26.49	30.12	24.85	24.4	24.83
4		Karnataka							
	Area	32.12	12.81	40.12	23.89	22.73	11.99	68.54	22.62
	Production	54.97	27.83	39.51	23.19	32.57	23.33	84.73	39.73
	Productivity	33.11	28.21	23.99	22.32	23.02	24.24	29.29	27.09
5		Andhra Pradesh							
	Area	85.59	34.43	59.35	16.1	29.55	30.72	93.73	41.12 ^a
	Production	84.92	33.93	48.18	28.72	20.69	21.48	92.74	36.62 ^a
	Productivity	16.4	14.39	29.25	29.93	19.61	20.7	27.55	24
6		Gujarat							
	Area	46.47	30.44	79.55	20.61	42.62	30.3	89.01	49.59
	Production	44.53	18.62	77.79	29.41	58.48	36.84	109.49	68.59
	Productivity	19.75	20.54	22.65	22.88	26.35	23.57	25.31	24.85
7		Chhattisgarh							
	Area	63.05	44.35 ^a	73.21	21.14	12.24	10.45	87.76	37.91 ^a
	Production	62.66	47.13 ^a	72.68	15.14	30.72	23.75	92.32	55.74 ^a
	Productivity	15.28	14.7	22.44	15.65	30.18	29.51	22.5	22.7
8		All India							
	Area	27.92	5.26	17.59	4.87	7.18	5.91	36.2	7.37
	Production	35.69	8.99	27.15	11.9	14.48	14.9	42.14	18.65
	Productivity	11.03	8.62	14.94	13.04	17.65	16.51	15.06	14.71

Note: CV- Coefficient of Variation (%), CDV – Cuddy Della Valle Index (%), ^a Non-Significant

At all India level, soybean production marginal decreased at the rate of -1.14 per cent per annum. During Period-III, Gujarat shown significantly the highest increase in soybean yield by 3.97 per cent per annum followed by Karnataka (0.72%). While, Rajasthan, Chhattisgarh, Maharashtra, Madhya Pradesh and Andhra Pradesh recorded negative growth rate of -6.97, -3.91, -3.59, -1.89 and -0.69 per cent per annum in Period-III, respectively. At all India level also shown negative growth in soybean yield (-2.63%) during Period-III. In overall period from 1990-91 to 2019-20, Gujarat recorded the highest significant increase in soybean area at the rate of 10.07 per cent per annum followed by Maharashtra (10.04%), Rajasthan (8.82%) and Rajasthan (5.50%). While, Madhya Pradesh (2.55%) shown the low, but significant positive growth in area of soybean during overall period. All India level shown significantly positive growth in soybean area (4.60%) during overall period.

In case of soybean production in overall period, Gujarat registered significantly the highest growth rate (10.74%) per annum followed by Karnataka (10.41%), Maharashtra (9.99%) and Rajasthan (5.37%). While, Madhya Pradesh (3.15%) shown the low, but significant positive growth in production of soybean during overall period. At all India level, soybean production increased significantly at the rate of 5.10 per cent per annum during overall period. Thus, during last three decades, Gujarat, Karnataka and Maharashtra contributed considerably for increasing soybean production in India. In case of soybean productivity during overall period, Andhra Pradesh registered significantly the highest growth rate (1.64%) followed by Karnataka (1.46%), Gujarat (0.61%) and Madhya Pradesh (0.59%). While, Chhattisgarh, Rajasthan and Maharashtra shown the negative growth in productivity of soybean during overall period at all India level, soybean productivity increased significantly at the rate of 0.46 per cent per annum during overall period. Thus, during last three decades, soybean productivity marginally increased. Besides, Andhra Pradesh registered the highest mean productivity of soybean above 1302.53 kg/ha in all periods followed by Maharashtra (1126.77 kg/ha). However, India is far behind in soybean productivity in world that indicates

requirement for improvements in the yield of soybean by use of new research methodologies and by exploitation of recent advances in biology. Agarwal *et al.* (2013) [4] also reported similar results at national level for soybean in India. Their study revealed that soybean crop has shown unparalleled growth in area and production. However, large yield gaps exist between the potential and the actual yields and require intervention in soybean crop for improvement of productivity.

Instability in area, production and yield of soybean in major states of India

State-wise instability in area, production and productivity of soybean crop were measured for four periods and results are presented in [Table-2]. Among all the states, Andhra Pradesh (34.43%) and Gujarat (30.44%) showed the highest instability in soybean area during Period-I. While, Rajasthan (16.59%) showed medium instability in soybean area during Period-I. This reveals that during Period-I, the area under soybean relatively small and Period -I was introducing phase of soybean crop in many states.

In case of soybean production, the states of Andhra Pradesh (33.93%) have shown high instability in Period-I. Whereas, Madhya Pradesh and at all India level showed low instability in production of soybean in Period-I. Looking to the soybean productivity, Karnataka state recorded highest instability (28.21%) during Period-I. Besides, Gujarat (20.54%) and Maharashtra (16.19%) had shown medium instability in period-I. whereas, remaining other states under study and at all India level showed low instability in production in Period-I.

In Period-II, soybean area in Karnataka (23.89%) showed the highest instability. Chhattisgarh (21.14%), Gujarat (20.61%) and Andhra Pradesh (16.10%) showed medium instability. whereas, all other states under study and at all India level showed low instability in area in Period-II. While, In Period-II, soybean production in Gujarat (29.41%) showed the highest instability followed by Andhra Pradesh (28.72%), Maharashtra (25.42%) and Karnataka (23.19%). Besides, Madhya Pradesh (10.50%) had shown low instability in period-II. Whereas, all India level also showed low instability in production in Period-II [5-8].

While, in case of soybean productivity, Andhra Pradesh recorded the highest instability (29.93%) in Period-II. Besides, Rajasthan (26.49%), Gujarat (22.88%), Karnataka (22.32) and Chhattisgarh (15.65%) had shown medium instability in the period-II. All other states and at all India level showed low instability in soybean productivity in Period-II. Similar result for soybean production growth and instability in Maharashtra was reported by Sajesh *et al.* (2014) stated that erratic weather, volatile market price and lack of storage and market infrastructure caused instability in production.

In Period-III, soybean area in Andhra Pradesh (30.72%) and Gujarat (30.30%) showed the higher instability. In case of soybean production, Gujarat (36.84%) showed the higher instability. While, Maharashtra (26.35%), Chhattisgarh (23.75%), Karnataka (23.33%) and Rajasthan (20.37%) experienced medium instability during Period-III. While, Madhya Pradesh and at all India level recorded low instability in soybean production in Period-III. This indicates that during 2010s the soybean production has been reported medium variations in all the states under study except in Gujarat states.

In overall period from 1990-91 to 2019-20, Gujarat (49.59%) showed high instability in soybean area. While, Karnataka (22.62%) and Rajasthan (15.59%) showed medium instability in soybean area in overall period. Whereas, Maharashtra (10.48%) and Madhya Pradesh (9.81%) showed low instability in soybean area during last three decades. Whereas, study showed low instability in area during overall period at all India level. In overall study period, Gujarat (68.59%), Karnataka (39.73%) and Rajasthan (30.20%) had recorded having high instability in production. Whereas, all other states under study showed medium instability in production during overall period. Whereas, all states and at all India level under study showed low instability in productivity during overall period.

Looking to the state-wise scenario, Madhya Pradesh and Maharashtra state recorded the low instability in case of soybean area during all period. While, Gujarat state recorded the high instability in case of soybean area and production during the period-I, period-II and period-III. At all Indian level recorded the low instability in case of soybean area, production and productivity during all three decades.

Conclusion

All India level shown significantly positive growth in soybean area and production during overall period. During last three decades, Gujarat, Karnataka and Maharashtra contributed considerably for increasing soybean production in India. At all India level, soybean productivity increased significantly at the rate of 0.46 per cent per annum during overall period. Thus, during last three decades, soybean productivity marginally increased. However, India is far behind in soybean productivity in world that indicate requirement of improvements in the yield of soybean by use of new research methodologies and by exploitation of recent advances in biology.

Application of research: The important policy implications emerged are (1) Area and production of soybean crop increased considerably in last two decades and it has vast scope to increase further having large demand, and (2) Very low productivity of soybean in India compared to the world indicates that there exists a vast untapped yield potential, which can be achieved by research and extension efforts in India

Research Category: Agricultural Economics

Abbreviations:

CGRs-Compound Growth Rates

CV- Coefficient of Variation

CDV-Cuddy-Della Valle index

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Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, Karnataka, Andhra Pradesh and Chhattisgarh

Cultivar / Variety / Breed name: Soybean (*Glycine max* L.)

Conflict of Interest: None declared

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Ethical Committee Approval Number: Nil

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