



## Research Article

# GROWTH PERFORMANCE AND INSTABILITY OF CASTOR CROP

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**Abstract:** The research study conducted to analyze growth and instability of area, production and yield of castor crop in India, Gujarat and major castor producing district in Gujarat state for six different period. The time series data was collected for the period from 1970-71 to 2019-20. To examine growth and instability, compound annual growth rates (CAGRs) and Cuddy-Della Valle Index was used. The results of the growth and instability of the castor crop in India revealed that area of the castor negative in all the periods, except Period-II in which it increased significantly. However, in India the area and yield of castor has been noticed more stable during all the periods ranging from 5 to 23 per cent per annum, while production was relatively become unstable in Period-II (32.47%).

**Keywords:** Castor crop, Growth and Instability, Compound annual growth rate

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## Introduction

Castor is cultivated in 30 different countries on commercial scale, of which India, China and Brazil are the major castor growing countries accounting for 94.27 per cent of the world's production. India accounts for nearly 78 per cent of world's castor area and 91 per cent of world castor production and ranks first in both area and production in the world, followed by Brazil and China [1]. India not only continued, but also expanded the cultivation of castor seeds, especially in Gujarat, as its arid land was unsuitable for other rainfed crops; similarly, so with Rajasthan and to some extent Andhra Pradesh. As a result, India acquired a virtual monopoly in the cultivation of castor seeds in the world. India accounts for 95-96 per cent of world exports of castor oil. The world export of castor oil in 2020-21 (up to March-2021) was 6.83 lakh tons in which India contribution was 6.60 lakh tons [2]. Gujarat, Rajasthan, and Andhra Pradesh contribute about 99 per cent of the total castor seeds production in India. Gujarat is number one in producing state with share of about 86 per cent of the total India's castor seed production in 2020-21, followed by Rajasthan at 12 per cent, Andhra Pradesh and other states sharing 2 per cent. World's exports increased to 681.7 thousand tons in 2020-21 from 601.9 thousand tons in 2015-16, representing a growth of 13.25 per cent over the same period. Being a monopoly castor producer, India has also virtual monopoly position in castor oil exports, too. In 2020-21, India accounted for 96.81 per cent of total global castor oil export. Its main trading partner in this specific sector are China, Europe, Thailand, and Japan. In some countries the cake is used as a fertilizer. Poisons contained in the cake include ricin. Hence, study has been conducted to find out the growth and instability of castor crop in India, Gujarat, and major sowing districts in Gujarat state.

## Material and Methods

### Data collection

The study relied on secondary data pertaining to area, production, and yield of castor crop from India. The secondary data included area, production, and yield of the castor crop for the periods from 1970-71 to 2019-20 at district and state level.

These data were collected from various issues of Seasons and Crop Report of Gujarat, Agro Stat published by different sources and web database of Food and Agriculture Organization and IndiaStat.

### Compound annual growth rate (CAGR)

The Compound Growth Rates (CGRs) of castor crop area, production and yield at all-India, state and major sowing district level was computed for the periods viz., Period-I (1970-71 to 1979-80), Period-II (1980-81 to 1989-90), Period-III (1990-91 to 1999-2000), Period-IV (2000-01 to 2009-10), Period-V (2010-11 to 2019-20), and Period-VI (1970-71 to 2019-20) using the exponential function of the following specification:

$$Y_t = ab^t$$

Where,

$Y_t$  = Dependent variable;

$t$  = Time variable in years taking the value of 1, 2, 3, ...,  $n$ ;

$a$  = Intercept;

$b$  = Regression coefficient  $(1+r)$ ;

For the purpose of estimation, the equation is expressed in logarithmic form.

$$\log Y_t = \log a + t \log b$$

The value of  $\log b$  in equation (2) was computed using the formula,

$$\log b = \frac{(\sum t \log Y_t - (\sum t)(\sum \log Y_t / N))}{\sum t^2 - \left(\frac{(\sum t)^2}{N}\right)}$$

Where,

$N$  = Number of years.

Subsequently, the compound growth rate (%) was computed using the formula,

$$\text{Compound growth rate (r)} = [(\text{Antilog of } \log b) - 1] \times 100$$

$$t = \log b / \text{SE} (\log b)$$

$$\log (b) = \frac{\sum (Y_t - \bar{Y})^2 - \text{Log } b^* (\sum (Y_t) - \sum (Y_t)^2)}{(N-2) \sum (t - \bar{t})^2}$$

The calculated 't' values, was compared with the table 't' values and the significance was tested for 1 and 5 per cent, probability levels.

### Cuddy-Della Valle index

To examine the instability in area, production and yield of castor crop in all-India, state and major sowing district level the time series data was analysed for the periods viz., Period-I (1970-71 to 1979-80), Period- II (1980-81 to 1989-90), Period-III (1990-91 to 1999-2000), Period-IV (2000-01 to 2009-10), Period-V (2010-11 to 2018-19), and Period-VI (1970-71 to 2019-20). The Cuddy-Della Valle index are given by:

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

Where,

$I_x$  = Instability Index;

$CV$  = Coefficient of variation;

$R^2$  = Adjusted coefficient of multiple determination;

$$CV(\%) = \frac{S}{\bar{X}} \times 100$$

Where,

$S$  = Standard deviation

$\bar{X}$  = Arithmetic mean

### Results and Discussion

The results of mean, compound growth rates and Cuddy-Della Valle index as a measures of growth and instability of area, production and yield of castor in India, Gujarat and major castor producing districts for six different periods has been presented and discussed in this section.

#### Growth performance and instability of castor in India

The result of growth and instability of castor crop in India has been presented in [Table-1]. It revealed that area of the castor negative in all the periods, except Period-II in which at increased significantly. This is mainly due to the good breeding program and a good extension model in the year of 1980-81. The highest significantly increase in production and yield of castor in India was noticed in Period-IV to the tune of 6.20 and 6.77 per cent per annum respectively followed by Period-I and Period-III. While, in overall Period-VI (from 1970-71 to 2019-20) India has achieved significant growth rate in area, production and yield of castor to about 1.75, 5.40 and 3.59 per cent per annum respectively. However, in India the area and yield of castor has been noticed more stable during all the periods ranging from 5 to 23 per cent per annum, while production was relatively become unstable in Period-II (32.47%).

Table-1 Growth and instability of area, production and yield of castor crop India

Periods	Item	India		
		Area	Production	Yield
Period-I (1970-71 to 1979-80)	Mean	459.30	187.08	411.00
	CGR (%)	-0.84***	5.15***	6.04***
	CDVI	15.48	16.20	13.25
Period-II (1980-81 to 1989-90)	Mean	595.66	340.06	559.67
	CGR (%)	1.67***	3.33**	1.63***
	CDVI	11.46	32.47	22.64
Period-III (1990-91 to 1999-00)	Mean	728.03	751.38	1036.23
	CGR (%)	-0.31***	3.50***	3.83***
	CDVI	8.71	11.24	11.62
Period-IV (2000-01 to 2009-10)	Mean	772.02	853.69	1106.07
	CGR (%)	-0.53***	6.20***	6.77***
	CDVI	19.02	19.73	7.83
Period-V (2010-11 to 2019-20)	Mean	1022.76	1693.98	1663.70
	CGR (%)	-3.58***	-2.18***	1.45***
	CDVI	19.23	19.23	5.28
Period-VI (1970-71 to 2019-20)	Mean	715.55	765.24	955.33
	CGR (%)	1.75***	5.40***	3.59***
	CDVI	19.78	33.83	15.82

#### Growth performance and instability of castor in Gujarat state

The result of growth and instability analysis of castor crop in Gujarat state has been presented in [Table-2]. It revealed that significantly the highest increase in

area, production and yield of castor in Gujarat was noticed in Period-I to the tune of 11.52, 18.52 and 6.28 per cent per annum respectively followed by Period-IV and III. This is mainly due to the release of hybrid castor variety GCH-2 in 1985. This was in tune with the findings of Dhandhalya and Ardeshta (2018) [3].

The area under castor cultivation was found more stable during Period-III in Gujarat, whereas, yield remained more stable during Period-V but production showed high fluctuation in all four Periods. This might be because, through castor can tolerate moisture stress, but responds well to irrigation. The crop performance is poor, when the crop experiences moisture stress from seedling to flowering stages when monsoon is unevenly distributed.

Table-2 Growth and instability of area, production and yield of castor crop in Gujarat state

Periods	Item	Gujarat		
		Area	Production	Yield
Period-I (1970-71 to 1979-80)	Mean	74.98	80.30	1011.48
	CGR (%)	11.52***	18.52***	6.28***
	CDVI	12.71	19.84	12.27
Period-II (1980-81 to 1989-90)	Mean	190.65	222.42	1149.79
	CGR (%)	0.52**	1.67*	1.15***
	CDVI	30.86	44.03	25.96
Period-III (1990-91 to 1999-00)	Mean	342.63	601.48	1748.02
	CGR (%)	1.70***	4.36***	2.61***
	CDVI	9.54	12.57	7.25
Period-IV (2000-01 to 2009-10)	Mean	346.47	607.79	1738.58
	CGR (%)	2.25***	7.12***	4.76***
	CDVI	20.82	20.72	10.15
Period-V (2010-11 to 2019-20)	Mean	656.05	1326.92	2022.33
	CGR (%)	-1.02***	-1.31***	-0.30***
	CDVI	19.45	19.98	6.14
Period-VI (1970-71 to 2019-20)	Mean	322.16	567.78	1534.04
	CGR (%)	5.09***	7.10**	1.91***
	CDVI	29.58	37.28	14.60

#### Growth performance of castor in major districts of Saurashtra region

The result of growth analysis of castor crop in major districts of Saurashtra region has been presented in [Table-3]. It revealed that the highest rate of increase in area (26.07 %) and production (26.29 %) was observed in Kutch during Period-I, followed by Period-II and IV, the highest yield growth 5.25 per cent was observed in Period-II in Kutch district. The rate of area and production was high in Jamnagar during Period-III with the account of 5.19 and 14.62 per cent respectively. The yield of castor was high in Jamnagar during Period-IV with a mean of 2627 kg/ha. and in Period-V the yield growth remained negative (-0.34 %).

The highest rate of increase in area (19.29 %) and production (24.3 %) was observed in Rajkot during Period-II, followed by Period-III, but the result was non-significant, highest growth in yield of castor were noticed in Period-III in Rajkot with account of 11.55 per cent. The area and production of castor was high in Surendranagar during Period-II with a mean of 3.7 thousand ha and 4.6 thousand tones, respectively. Hence, the highest rate of increase in yield (5.01 %) was observed in Surendranagar during Period-IV, followed by Period-III.

In overall Period-VI (from 1970-71 to 2019-20) highest rate of area and production was found in Surendranagar district with account of 16.34 and 18.39 per cent respectively. While in highest rate of yield (4.84 %) was observed in Jamnagar district. Growth in area, production and yield of overall Saurashtra region was observed 6.73, 10.5 and 2.35 per cent respectively during Period-VI.

#### Growth performance and instability of castor in major districts of North Gujarat region

The result of growth analysis of castor crop in major districts of North Gujarat region has been presented in [Table-4]. In Banaskantha district the highest rate of increase in area, production and yield was observed during Period-I with account of 11.44, 29.11 and 15.36 per cent respectively, followed by Period-III. The area, production and yield of castor were very high in Banaskantha during Period-V with a mean of 3896.5 thousand ha, 5511.1 thousand tones and 2457 kg/ha, respectively. The highest rate of increase in area (16.93 %) and production (19.6 %) was observed in Gandhinagar district during Period-IV, followed by Period-II. The highest rate of increase in yield was observed in Period-III in Gandhinagar with account of 5.67 per cent, followed by Period-IV.

Table-3 Growth in area, production and yield of castor crop in major districts of Saurashtra region

Periods		Period-I (1970-71 to 1979-80)		Period-II (1980-81 to 1989-90)		Period-III (1990-91 to 1999-00)		Period-IV (2000-01 to 2009-10)		Period-V (2010-11 to 2019-20)		Period-VI (1970-71 to 2019-20)	
Item		Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)
Kutch	A	117.3	26.07**	267.3	4.91***	369.1	-1.49***	547.3	0.54***	959.9	-3.35**	452.18	5.56**
	P	82.4	26.29*	211.8	17.95	385.8	1.96*	895.6	2.69**	1897.1	-6.91	694.54	9.22
	Y	714.2	-0.06**	475	5.25	1016.9	3.48**	1610.2	2.15***	1935.6	-3.69**	1150.3	3.64
Jamnagar	A	16	1.42	29.5	2.68	137.7	5.19*	104.9	-4.09***	117.2	-11.91	81.06	5.27
	P	15	3.36	34.3	3.7	268.4	14.62	271.4	8.61*	340.8	-14.68	185.98	8.57
	Y	468.6	-8.84	1037.3	11.21**	1852.8	8.95*	2627.3	12.89**	2900.2	-3.05**	1777.2	4.84*
Rajkot	A	2.1	8.77**	11.2	19.29	160.8	2.39**	85.2	-4.72*	114.4	-9.03**	74.74	10.48
	P	2.3	8.76*	12.7	24.3	416	14.22	203.1	10.01	206.4	-10.47**	168.1	12.64
	Y	1066.6	-0.01***	1106.7	2.19**	2542.6	11.55**	2506.9	15.56**	1927.7	-1.49**	1830.1	1.96**
Surendranagar	A	2.1	5.7*	3.7	31.78***	43.5	-6.45*	170.1	16.04**	587.5	-1.52**	161.38	16.34
	P	2.2	6.24*	4.6	33.55*	81	-1.89**	378.1	21.59***	1121.3	-11.6	317.44	18.39
	Y	1033.3	0.52***	1117.7	1.38**	1944	4.1***	2176.8	5.01***	1917.3	-10.25*	1637.8	1.7***
Overall	A	138.5	20.4**	312.7	5.69***	712.1	0.19***	908.5	2.29***	1780	-3.05***	770.4	6.73**

Table-4 Growth in area, production and yield of castor crop in major districts of North Gujarat region

Periods		Period-I (1970-71 to 1979-80)		Period-II (1980-81 to 1989-90)		Period-III (1990-91 to 1999-00)		Period-IV (2000-01 to 2009-10)		Period-V (2010-11 to 2019-20)		Period-VI (1970-71 to 2019-20)	
Item		Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)
Banaskantha	A	179.2	11.44***	556	-3.84	586.3	4.01***	755.3	-0.29***	3896.5	-18.89	1194.6	4.88
	P	202	29.11*	728.2	-1.19	1164.2	4.37***	1513.8	1.7**	5511.1	-8.88	1823.8	7.31
	Y	980.2	15.36**	1325.8	2.73***	1976.6	0.34***	1981.4	1.96***	2456.7	1.88***	1744.1	2.64***
Gandhinagar	A	10.4	1.55***	79.7	8.39**	112.2	-0.83***	199.9	16.93***	272.6	-2.09***	134.96	7.58*
	P	9.7	2.77***	90.6	9.62*	219.1	4.75***	386.5	19.6**	632.6	-0.61***	267.7	10.17*
	Y	995.7	1.69***	1145.7	1.14**	1945.6	5.67***	1982.4	3.8***	2321.6	1.5***	1678.2	2.33***
Mehsana	A	278.5	13.8***	524.6	-4.6**	832.7	4.27***	481.6	-4.01**	764.5	2.71***	576.38	2.06**
	P	349.7	21.33***	704.6	-4.57*	1559.2	5.25***	813.2	2.12**	1712.6	4.52***	1027.8	3.78**
	Y	1183.5	6.58***	1340.1	0.04**	1866.5	0.93***	1752.3	6.4***	2232.8	1.77***	1675.0	1.68***
Sabarkantha	A	57	4.65***	158.8	19.51***	528.9	-0.45***	411.8	3.36***	422.3	-14.3**	315.76	4.86
	P	59.4	7.64**	219	19.55	937.7	0.04***	544.4	16.3**	808.6	-11.56**	513.82	6.45
	Y	1058.1	0.76***	1202	-1.02*	1773.3	0.49***	1277.6	12.53***	1991.6	3.2***	1460.5	1.43***
Overall	A	530	11.55***	1324	-0.70**	2065	2.56***	1854	0.53***	5361	-14.50	2227	4.17**
	P	626	21.46***	1747	0.28*	3885	3.72***	3263	5.01***	8670	-6.38	3638	5.92*

Table-5 Growth in area, production and yield of castor crop in major districts of Middle Gujarat region

Periods		Period-I (1970-71 to 1979-80)		Period-II (1980-81 to 1989-90)		Period-III (1990-91 to 1999-00)		Period-IV (2000-01 to 2009-10)		Period-V (2010-11 to 2019-20)		Period-VI (1970-71 to 2019-20)	
Item		Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)	Mean	CGR (%)
Ahmedabad	A	27.1	9.27***	192.8	4.42**	269.2	-0.05***	144.2	-0.13*	464	5.53***	219.46	5.5
	P	25.7	10.64***	199.8	2.56	400.6	4.79***	193.5	5.47*	791.2	5.17***	322.16	7.19
	Y	833.5	2.5**	1014.1	-0.77*	1472.7	4.81***	1379.7	5.78***	1724.2	-0.34***	1284.8	2.01***
Kheda	A	19.1	-3.54*	36.7	10.87**	118.2	5.19*	101.7	3**	130.8	-7.46*	81.3	4.83*
	P	17.7	-2.31	44.3	13.02*	152.8	7.22	133.7	12.73***	215.6	-5.41*	112.82	6.33*
	Y	1117.7	-0.7**	1121.5	1.31**	1271.5	2.43***	1320.3	9.41***	1674.1	2.25***	1301.0	1.14***
Vadodara	A	9.2	8.07**	18.4	7.89**	131.4	0.89***	122.3	7.8**	323.5	9.04***	120.96	9.36**
	P	8.5	9.27***	22.2	9.11	170.2	-0.73***	162.5	13.79***	635.1	9.22**	199.7	11.17*
	Y	940.3	1.11***	1125.7	1.1**	1296.7	-1.66***	1355.4	6.68***	1943.7	0.14***	1332.3	1.69***
Overall	A	57	4.05***	250	5.53**	521	1.31***	370	3.28**	920	4.76***	424	6.03**
	P	54	5.41***	268	4.65	726	3.96***	492	9.43***	1644	5.16***	637	7.76*
	Y	970	0.73***	1063	0.53***	1258	1.51***	1261	5.49***	1583	0.44***	1227	1.23***

Table-6 Instability in area, production and yield of castor crop in major districts of Saurashtra region

Periods		I (1970-71 to 1979-80)	II (1980-81 to 1989-90)	III (1990-91 to 1999-00)	IV (2000-01 to 2009-10)	V (2010-11 to 2019-20)	VI (1970-71 to 2019-20)
Item		CDVI	CDVI	CDVI	CDVI	CDVI	CDVI
Kutch	A	41.82	30.13	26.76	20.97	33.27	41
	P	48.61	98.46	46.39	32.36	37.34	65.07
	Y	38.85	65.03	32.13	17.4	28.29	35.46
Ahmedabad	A	21.4	31.59	11.06	48.95	14.87	47.71
	P	26.59	57.02	27.5	41.49	14.19	55.88
	Y	39.64	45.32	18.9	14.85	15.79	25.77
Jamnagar	A	52.74	57.45	51.54	19.31	65.03	72.45
	P	55.93	70.1	59.67	39.28	63.53	79.51
	Y	50.89	30.03	41.05	30.19	29.82	39.03
Rajkot	A	37.67	75.05	37.41	50.39	47.56	82.9
	P	53.01	85.81	53.66	62.88	43.43	108.09
	Y	20.93	31.21	44.31	32.39	39.85	51.15
Surendranagar	A	40.57	69.95	37.3	31.01	31.59	92.26
	P	50.45	100.69	32.35	28.8	38.97	107.27
	Y	19.16	28.22	20.26	23.21	24.8	31.26
Overall	A	39.37	31.87	27.01	16.59	27.06	41.35
	P	43.54	79.26	38.95	20.70	33.94	59.23
	Y	11.52	23.53	25.38	19.05	22.70	27.73

In Mehsana district the highest rate of area, production and yield was observed in Period-I with the account of 13.8, 21.33 and 6.58 per cent respectively, followed by Period-III. In Sabarkantha district the highest rate of area and production was observed in Period-II with the account of 19.51 and 19.55 per cent respectively, followed by Period-I and IV. While in highest rate of yield (12.53 %) was observed

in Sabarkantha district. In overall Period-VI (from 1970-71 to 2019-20) highest rate of area and production were found in Gandhinagar district with account of 7.58 and 10.17 % respectively. While in highest rate of yield (2.64 %) was observed in Banaskantha district. Growth in area, production and yield of overall North Gujarat region was observed 4.17, 5.92 and 1.67 % respectively during Period-VI.

## Growth Performance and Instability of Castor Crop

*Table-7 Instability in area, production and yield of castor crop in major districts of North Gujarat region*

Periods		I (1970-71 to 1979-80)	II (1980-81 to 1989-90)	III (1990-91 to 1999-00)	IV (2000-01 to 2009-10)	V (2010-11 to 2019-20)	VI (1970-71 to 2019-20)
Item		CDVI	CDVI	CDVI	CDVI	CDVI	CDVI
Banaskantha	A	22.84	34.06	12.71	29.85	141.89	238.8
	P	47.32	42.83	18.65	37.1	163.46	222.3
	Y	34.07	22.94	7	18.25	15.86	19.65
Gandhinagar	A	17.88	30.58	8.38	27.99	7.67	31.61
	P	24.24	40.25	20.65	30.74	12.38	36.43
	Y	13.7	26.98	13.54	11.91	6.82	16.65
Mehsana	A	10.72	27.03	14.71	36.18	16.63	36.15
	P	15.86	41.1	17.06	30.48	16.93	41.3
	Y	11.56	30.55	7.26	6.85	5.32	15.73
Sabarkantha	A	20.75	32.7	11.02	16.58	31.58	53
	P	45.68	73.99	17.14	27.04	32.06	62.41
	Y	26.93	38.65	12.91	21.88	4.61	26.82
Overall	A	7.93	28.52	5.28	21.97	105.34	132.30
	P	19.12	41.00	7.70	25.43	104.13	114.77
	Y	10.07	19.65	5.54	7.17	5.29	12.47

*Table-8 Instability in area, production and yield of castor crop in major districts of Middle Gujarat region*

Periods		I (1970-71 to 1979-80)	II (1980-81 to 1989-90)	III (1990-91 to 1999-00)	IV (2000-01 to 2009-10)	V (2010-11 to 2019-20)	VI (1970-71 to 2019-20)
Item		CDVI	CDVI	CDVI	CDVI	CDVI	CDVI
Ahmedabad	A	21.4	31.59	11.06	48.95	14.87	47.71
	P	26.59	57.02	27.5	41.49	14.19	55.88
	Y	39.64	45.32	18.9	14.85	15.79	25.77
Kheda	A	41.92	49.61	53.89	37.96	49.22	60.28
	P	48.88	64.8	69.43	37.02	47.17	65.89
	Y	31.68	28.84	29.94	17.52	9	23.77
Vadodara	A	29.79	37.68	12.63	29.72	26.54	55.87
	P	29.45	59.38	16.13	23.78	30.57	77.66
	Y	20.12	28.79	9.44	16.91	8.61	19.13
Overall	A	19.75	31.80	11.36	35.14	18.19	39.46
	P	26.59	55.95	15.67	26.24	20.19	51.64
	Y	19.53	25.39	10.44	7.58	5.65	14.59

### Growth performance and instability of castor in major districts of Middle Gujarat region

The result of growth analysis of castor crop in major districts of Middle Gujarat has been presented in [Table-5]. The result revealed that the highest rate of increase in area (9.27 %), production (10.64 %) and yield (2.5 %) was observed in Ahmedabad during Period-I, followed by Period-IV and V. In Kheda district the highest rate of area and production was observed in Period-II with the account of 10.87 and 13.02 per cent respectively, followed by Period-III and IV. While highest rate of yield was observed in Period-IV with account of 9.41 per cent. The highest rate of increase in area (9.04 %) was observed in Vadodara district during Period-V, followed by Period-I and II. The highest rate of increase in production and yield was observed in Period-IV in Vadodara with account of 13.79 and 6.68 per cent, followed by Period-I. In overall Period-VI (from 1970-71 to 2019-20) highest rate of area and production were found in Vadodara district with account of 9.36 and 11.17 per cent respectively. While in highest rate of yield (3.64 %) was observed in Kutch district. Growth in area, production and yield of overall Middle Gujarat region was observed 6.03, 7.76 and 1.23 per cent respectively during Period-VI.

### Instability of castor in major districts of Saurashtra region

The result of instability analysis of castor crop in major districts of Saurashtra region has been presented in [Table-6]. In Kutch district the area of castor has been noticed more stable in all the periods but production and yield were noticed high instability in Period-II. The area, production and yield of castor in Jamnagar has been noticed very high instability in all the periods, accepted Period-IV. In Rajkot the area and production of castor has been noticed very high instability in the Period-II ranging from 75 to 85 per cent per annum, while yield was relatively become stable in Period-II (31.21 %). In Surendranagar the area and production of castor has been noticed very high instability in Period-II ranging from 70 to 100 per cent per annum, while yield was relatively become stable in all the periods. In overall Period-VI (from 1970-71 to 2019-20) area of castor cultivation was observed very high instable in Surendranagar district with account of 92.26 per cent. While production (108.09%) and yield (51.15%) observed highly instable in Rajkot district. Instability in area, production and yield of overall Saurashtra region was observed 41.35, 59.23 and 27.73 per cent respectively during Period-VI.

### Instability of castor in major districts of North Gujarat region

The result of instability analysis of castor crop in major districts of North Gujarat region has been presented in [Table-7]. In Banaskantha the area and production of castor has been noticed very high instability in Period-V ranging from 141 to 164 per cent per annum, while yield was relatively become stable in Period-III (7.0 %). The area, production and yield under castor cultivation was found more stable during Period-V in Gandhinagar, followed by Period-III and I. The area and production of castor was found more stable during Period-I in Mehsana and yield remained more stable during Period-V.

The area under castor cultivation was found more stable during Period-III in Sabarkantha, whereas, yield remained more stable during Period-V but production showed high fluctuation in Period-II.

In overall Period-VI (from 1970-71 to 2019-20) area, production and yield of castor cultivation was observed very high instable in Banaskantha district with account of 238.8, 222.3 and 19.65 per cent respectively. Instability in area, production and yield of overall North Gujarat region was observed 132.30, 114.77 and 12.47 per cent respectively during Period-VI.

### Instability of castor in major districts of Middle Gujarat region

The result of instability analysis of castor crop in major districts of Middle Gujarat has been presented in [Table-8]. The area under castor cultivation was found more stable during Period-III in Ahmedabad, whereas, production and yield remained more stable during Period-V and IV respectively. In Kheda the area and production of castor has been noticed more stable in Period-IV and yield of castor has been noticed more stable in Period-V.

The area and production of castor was found more stable during Period-III in Vadodara and yield remained more stable during Period-V. In overall Period-VI (from 1970-71 to 2019-20) area (60.28%), production (77.66%) and yield (35.46%) of castor cultivation was observed very high instable in Kheda, Vadodara and Kutch district respectively.

Instability in area, production and yield of overall Middle Gujarat region was observed 41.35, 59.23 and 27.73 per cent respectively during Period-VI. Instability in area, production and yield of overall Middle Gujarat region was observed 39.46, 51.64 and 14.59 per cent respectively during Period-VI.



## Conclusion

The results of the growth and instability of the castor crop in India revealed that area of the castor negative in all the periods, except Period-II in which it increased significantly. The highest significant increase in production and yield of castor in India was noticed in Period-IV to the tune of 6.20 and 6.77 per cent per annum respectively. However, in India the area and yield of castor has been noticed more stable during all the periods ranging from 5 to 23 per cent per annum, while production was relatively become unstable in Period-II (32.47%). The highest increase in area, production and yield of castor in Gujarat was noticed in Period-I to the tune of 11.52, 18.52 and 6.28 per cent per annum. The area under castor cultivation was found more stable during Period-III in Gujarat, whereas, yield remained more stable during Period-V but production showed high fluctuation in all four Periods.

**Application of research:** Study of growth and instability of castor crop

**Research Category:** Agri-Business Management

**Abbreviations:** CAGR-Compound Annual Growth Rate, CDVI-Cuddy-Della Valle Index

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**Study area / Sample Collection:** Major castor sowing district in Gujarat state

**Cultivar / Variety / Breed name:** Castor

**Conflict of Interest:** None declared

**Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.

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