



RESEARCH PAPER

Trend analysis of area, production and productivity in pigeonpea

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Abstract : The present study has been analysed the trend in area, production and productivity of pigeon pea and the instability by Cuddy Della Valle index. The study has been carried out based on secondary data and the data was collected for the periods from 2007-08 to 2018-19. Compound annual growth rate, co-efficient of variation and instability index was computed. The growth rate of area and production of pigeonpea in India showed and significant positive at 1 per cent and 5 per cent level, respectively and productivity showed insignificant positive growth rate. The growth rate of area and production of pigeonpea of Karnataka showed significant positive trend at 5 per cent level and productivity showed insignificant positive growth rate. The increase in production occurs due to increase in area as well as interactions of area and productivity of pigeonpea in the study period. Thus, there is a need to take up productivity enhancing measures in pigeonpea like varietal improvement, improved cultural practices, disease control measures and irrigation facilities. The instability indices for area, production and productivity for pigeonpea is positive which indicates less risk in growing pigeonpea in future.

Key Words : Compound annual growth rate, Co-efficient of variation, Instability index

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INTRODUCTION

The pigeonpea (*Cajanus cajan*) is a perennial legume belongs to the family Fabaceae. Pigeonpea is an important legume crop of rainfed agriculture in semi arid tropics and has the status of staple diet throughout the country. Pigeonpea is rich source of protein and supplies a major share of the protein requirement of the vegetarian population of the country. It is mainly eaten in the form of split pulse as 'dal' which is considered to be primary

accompaniment to rice or *Roti* (flat bread). Seeds are rich in iron and iodine, besides essential amino acids like lysine, tyrosine, cystine and arginine. The outer covering of its seed together with part of the kernel provides a valuable feed for milch cattle. The husk of pods and leaves obtained during threshing used as a valuable cattle feed. Woody parts of the plant are used for fuel.

Pigeonpea is widely cultivated in all tropical and semi-tropical regions. World production of pigeonpea was

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4.49 million tons (2017-18). About 63 per cent of pigeonpea produced from India. The total area under pigeonpea is 5.4 million hectares. India accounts for 72 per cent of area grown to pigeonpea. The total area under pigeonpea in India is 4,550 thousand hectares (2018-19) which was mainly contributed by Maharashtra, Karnataka, Andhra Pradesh, Uttar Pradesh and Madhya Pradesh. From this area, 3,315 thousand metric tonnes of pigeonpea was produced in 2018-19. During this period, productivity of pigeonpea was recorded as 729 kg per hectare.

Identifying the existing trends in area, production and productivity plays an important role in the way of development (Sharma, 2012). By estimating the trend in area, production and productivity of pigeonpea, gap in demand and supply can also be worked out (Sharma, 2013). In this paper, an attempt is made to study the trend in area, production and productivity of pigeonpea in India.

Objective of the study:

The specific objective is to study the growth rates in area, production and productivity of pigeonpea in India.

MATERIAL AND METHODS

The study was based on secondary data collected from various published sources (Anonymous, 2020). Time series data for the period from 2007-08 to 2018-19 pertaining to area, production and productivity of pigeonpea crop for India as a whole and state wise data were collected from Ministry of Agriculture and Farmers Welfare, Government of India and district wise data of Karnataka state was collected from Directorate of Economics and Statistics, Government of Karnataka. Compound annual growth rate, co-efficient of variation and instability index were analysed for separately for area, production and productivity of pigeonpea as a whole for India, state wise and district wise of Karnataka state.

To analyse the trend in area, production and productivity of pigeon pea, exponential functional form is fitted. Based on exponential function, the compound annual growth rate is also computed.

$$Y_t = A B^t u_t \quad \dots(1)$$

where,

Y_t = Data on area or production or productivity in the year 't'

A = Intercept indicating Y in the base period (t = 0)

B = (1 + g) regression co-efficient

t = Time period in years

u_t = Disturbance term for the year 't'

g = Average compound growth rate to be estimated

Eq. (1) was converted into logarithmic form in order to facilitate the use of linear regression.

Taking logarithm on both sides of the eq. (1)

$$\ln Y_t = \ln A + t (\ln B) + \ln u_t$$

This can be rewritten in the following form

$$Q_t = a + bt + v_t \quad \dots(2)$$

where,

$$Q_t = \ln Y_t$$

$$a = \ln A$$

$$b = \ln B$$

$$v_t = \ln u_t$$

The values of 'a' and 'b' are estimated by using Ordinary Least Squares (OLS) estimation technique.

Later the original parameter 'A' and 'B' in eq. (1) were obtained by taking anti-logarithm of the values 'a' and 'b' in the eq. (2) as:

$$A = \text{Anti } \ln a$$

$$B = \text{Anti } \ln b.$$

Average compound annual growth rate was calculated as:

$$\text{CAGR} = (B-1) \times 100$$

The significance of the regression co-efficient was tested using student's 't' test.

Instability index:

The agricultural instability can be measured by various methods, such as the co-efficient of variation, dispersion, Cuddy Della Valle Index, Coppock Instability index, etc. The present study applies the Cuddy Della Valle Index for measuring the instability. Cuddy Della Valle index first de-trends the given series and gives a clear direction about the instability. The use of co-efficient of variation as a measure to show the instability in any time series data has some limitation. If the time series data exhibit any trend, the variation measured by co-efficient of variation can be over-estimated, *i.e.* the region which has growing production are at constant rate will score high in instability of production if co-efficient of variation is applied for measuring instability. As against that, Cuddy-Della Valle index attempts to de-trend the co-efficient of variation by using co-efficient of determination. Cuddy Della Valle Index was originally developed by Cuddy and Valle (1978) for measuring

the instability in time series data that is characterized by trend.

In order to study the stability of pigeonpea with respect to area, production and productivity, co-efficient of variation was estimated using the expression given below.

The co-efficient of variation is a statistical measure of the dispersion of data points in a data series around the mean. The co-efficient of variation represents the ratio of the standard deviation to the mean and it is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from one another.

$$\text{Co-efficient of variation} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

To measure the magnitude of variability in area, production and productivity for the total period, the co-efficient of variation (%) was computed. Further the instability index was also calculated to examine the instability in area, production and productivity pigeonpea in country over the time period by using the following formula:

$$\text{Instability index (I)} = \sqrt{1 - R^2} \times CV$$

RESULTS AND DISCUSSION

Time series is likely to show a tendency to either increase or decrease, over a long period. This tendency is called as trend. For the analysis of trend in area, production and productivity of pigeonpea, the data of 12 years *i.e.*, from 2007-08 to 2018-19 was considered. Analysis is done separately for area, production and productivity as a whole for India, state wise and district wise of Karnataka state.

The area under pigeonpea has been increased from 3,726 thousand hectares in 2007-08 to 4,450 thousand hectares in 2018-19 with an average area of 4,073.67 thousand hectares as presented in Table 1. The compound annual growth rate (CAGR) of area for the period 2007-08 to 2018-19 was 2.51 per cent which shows highly significant at 1 per cent level and the co-efficient of variation was found to be 13.13 per cent. The R^2 value was 0.73 which indicates that 73 per cent of the variation in the area was explained over the years.

The production of pigeonpea during the study period was increased from 3,076 thousand MT in 2007-08 to 3,315 thousand MT in 2018-19 with an average annual production of 3113.75 thousand MT. The compound

Table 1 : Growth rate of area, production and productivity of pigeonpea in India

Sr. No.	Year	Area ('000 hectare)	Production ('000 MT)	Productivity (kg/ha)
1.	2007-08	3726	3076	826
2.	2008-09	3378	2266	671
3.	2009-10	3466	2465	711
4.	2010-11	4367	2861	655
5.	2011-12	4007	2654	662
6.	2012-13	3893	3023	776
7.	2013-14	3904	3174	813
8.	2014-15	3854	2807	729
9.	2015-16	3963	2561	646
10.	2016-17	5338	4873	913
11.	2017-18	4438	4290	967
12.	2018-19	4550	3315	729
	Total	48884	37365	9098
	Mean	4073.67	3113.75	758.17
	Std	534.68	759.59	104.23
	CV	13.13	24.39	13.75
	CAGR (%)	2.51 **	3.92*	1.32
	R ²	0.73	0.76	0.77
	Instability	6.81	11.88	6.54

Source: Ministry of Agriculture and Farmers Welfare, Govt. of India

Note: Std: Standard deviation; CV: Co-efficient of variation; CAGR: Compound annual growth rate; R²: Co-efficient of multiple determination * and ** indicate significance of values at P=0.05 and 0.01, respectively

annual growth rate (CAGR) of production for the period 2007-08 to 2018-19 was 3.92 per cent which shows significant at 5 per cent level. The co-efficient of variation was found to be moderately high with a value of 24.40 per cent. The increase in production occurs due to increase in area as well as interactions of area and productivity of pigeonpea in the study period. The R^2 value was 0.76 which indicates that 76 per cent of the variation in the production of pigeonpea was explained over the years.

Similarly, the productivity of pigeonpea during the study period was fluctuating over the year which was 826 MT per hectare in 2007-08 and 729 MT per hectare in 2018-19 with an average annual productivity of 758.17 MT per hectare. The compound annual growth rate (CAGR) of productivity for the period 2007-08 to 2018-19 was 1.38 per cent which was found insignificant. The co-efficient of variation was found to be 13.75 per cent. The R^2 value was 0.77 which indicates that 77 per cent of the variation in the productivity of pigeonpea was explained by pigeonpea productivity in India over the years.

The instability indices for area, production and productivity for pigeonpea are 6.81 per cent, 11.88 per cent and 6.54 per cent, respectively. The increase in production occurs due to increase in area as well as interactions of area and productivity of pigeonpea in the study period. The growing of pigeonpea is not risky as the co-efficient of variation of area, production and productivity are 13.13 per cent, 24.39 per cent and 13.75 per cent, respectively. Hence, the Null hypothesis is rejected since there is instability in the area, production and productivity of pigeonpea.

During the study period from 2007-08 to 2018-19, it was observed that the pigeonpea scenario in India has been incessantly fluctuating over the years. The results depicted that the area, production and productivity of pigeonpea in India has shown an upward trend. There has been spectacular growth in area, production and productivity of pigeonpea was observed after 2016-17. This might be due to the increase in demand for pigeonpea, better prices, relatively higher income with improved management practices and production technology in recent years encouraged in growth in

Table 2 : Growth rate of area under pigeonpea in different states

Sr. No.	Year	Maharashtra	Karnataka	Madhya Pradesh	Uttar Pradesh	Andhra Pradesh	Gujarat	Bihar	Jharkhand	Odisha	Chhattisgarh	Other states
1.	2007-08	1175	681	325	368	463	265	34	117	137	54	107
2.	2008-09	1009	597	321	315	443	266	28	103	139	53	104
3.	2009-10	1093	604	362	305	463	266	28	61	133	60	91
4.	2010-11	1302	891	488	344	297	277	26	104	135	55	448
5.	2011-12	1233	767	535	320	183	244	22	114	142	54	393
6.	2012-13	1180	660	531	311	204	228	22	196	141	52	369
7.	2013-14	1141	824	464	301	185	210	22	197	139	51	371
8.	2014-15	1210	728	521	287	151	214	20	196	138	53	336
9.	2015-16	1237	657	579	265	220	229	24	197	138	64	353
10.	2016-17	1435	1214	690	338	350	347	21	235	136	66	506
11.	2017-18	1241	885	647	282	279	271	18	194	138	58	426
12.	2018-19	1261	1483	213	251	250	254	17	231	144	68	377
	Total	14517	9991	5675	3687	3488	3071	282	1944	1660	688	3881
	Mean	1209.75	832.58	472.91	307.25	290.63	255.95	23.51	162.04	138.33	57.34	323.39
	Std	106.56	266.50	142.47	33.39	113.98	36.64	4.76	58.23	3.04	5.82	141.85
	CV	8.81	32.01	30.13	10.87	39.22	14.32	20.23	35.94	2.19	10.15	43.86
	CAGR	1.48*	5.58*	2.41	-2.13 **	-5.14	0.05	-4.82	10.08	0.22	1.63*	13.77
	(%)							**	**			**
	R^2	0.84	0.77	0.99	0.78	0.91	0.67	0.97	0.92	0.69	0.88	0.85
	Instability	3.51	15.42	3.56	5.11	12.09	8.19	3.50	10.23	1.23	3.59	16.99

Source: Ministry of Agriculture & Farmers Welfare, Govt. of India

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

pigeonpea production. The results are in similar with the Saraswathi *et al.* (2012) who reported that improvement management practices, higher income, better practices has direct link to the growth in area, production and productivity of major crops in Karnataka. And similar result was reported by Karunakaran (2013).

The data in Table 2 shows the area under pigeonpea in different states of India for the period from 2007-08 to 2018-19. The result depicts that the states like Maharashtra, Karnataka, Madhya Pradesh contributes more than 50 per cent of total area under pigeonpea in India. The area under pigeonpea in Maharashtra has been increased from 1,175 thousand hectares in 2007-08 to 1,261 thousand hectares in 2018-19 with an average of 1,209.75 thousand hectares which contributes about 29.70 per cent when compared to the average mean value of area under pigeonpea in India. The compound annual growth rate was found to be 1.48 per cent with significant at 5 per cent level and the co-efficient of variation was 8.81 per cent. The area under pigeonpea in Karnataka has been increased from 681 thousand hectares in 2007-08 to 1,483 thousand hectares in 2018-19 with an average of 832.58 thousand hectares which contributes about 20.43 per cent when compared to the

average mean value of area under pigeonpea in India. The compound annual growth rate was found to be 5.58 per cent with significant at 5 per cent level and the co-efficient of variation was 32.01 per cent. The average area under pigeonpea in Madhya Pradesh for the period from 2007-08 to 2018-19 was 472.91 thousand hectares which contributes about 11.61 per cent when compared to the average mean value of area under pigeonpea in India. The compound annual growth rate was found to be 2.41 per cent which was found insignificant and the co-efficient of variation was 30.13 per cent. The R² value 0.77 indicates that 77 per cent of the total variation was explained regarding the area of pigeonpea in Karnataka.

Growth rate of production under pigeonpea in different states of India for the period from 2007-08 to 2018-19 is represented in the Table 3. The production under pigeonpea in Maharashtra has been fluctuated from 1,083 thousand MT in 2007-08 to 834 thousand MT in 2018-19 with an average of 932.89 thousand MT. The compound annual growth rate was found to be 1.01 per cent which was found insignificant and the co-efficient of variation was 26.97 per cent. The production under pigeonpea in Karnataka has been increased from 485 thousand MT in 2007-08 to 948 thousand MT in 2018-19

Table 3 : Growth rate of production under pigeonpea in different states

Sr. No.	Year	('000 MT)										
		Maharashtra	Karnataka	Madhya Pradesh	Uttar Pradesh	Andhra Pradesh	Gujarat	Bihar	Jharkhand	Odisha	Chhattisgarh	Other states
1.	2007-08	1083	485	218	328	302	294	35	94	113	28	96
2.	2008-09	605	315	258	288	202	263	33	64	119	31	88
3.	2009-10	919	282	308	202	203	241	42	53	112	31	72
4.	2010-11	976	529	165	309	114	273	37	71	124	24	240
5.	2011-12	871	354	334	334	55	257	34	103	115	23	174
6.	2012-13	966	366	351	325	98	270	47	202	129	32	236
7.	2013-14	1034	588	332	271	104	209	37	205	124	31	240
8.	2014-15	726	474	511	174	76	235	29	200	124	34	225
9.	2015-16	557	242	625	183	132	258	37	178	123	30	198
10.	2016-17	1496	909	782	363	133	401	33	236	120	40	361
11.	2017-18	1128	762	839	331	120	337	29	222	124	35	364
12.	2018-19	834	948	180	272	46	308	32	234	147	32	282
	Total	11195	6254	4902	3380	1584	3345	423	1863	1473	371	2575
	Mean	932.89	521.13	408.54	281.70	132.00	278.75	35.22	155.22	122.78	30.92	214.60
	Std	251.56	238.91	229.09	63.61	72.50	51.22	5.29	71.82	9.17	4.41	96.53
	CV	26.97	45.84	56.08	22.58	54.93	18.38	15.01	46.27	7.47	14.27	44.98
	CAGR (%)	1.01	7.60*	8.35	-0.51	-8.92*	1.93	-1.63	14.32 **	1.36*	2.26	13.32**
	R ²	0.48	0.68	0.97	0.67	0.92	0.75	0.33	0.95	0.87	0.66	0.87
	Instability	19.37	25.89	10.19	12.91	15.73	9.26	12.28	10.03	2.67	8.32	16.22

Source: Ministry of Agriculture and Farmers Welfare, Govt. of India

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

with an average of 521.13 thousand MT. The compound annual growth rate was found to be 7.60 per cent with significant at 5 per cent level and the co-efficient of variation was 45.84 per cent. The average production under pigeonpea in Madhya Pradesh for the period from 2007-08 to 2018-19 was 408.54 thousand MT. The compound annual growth rate was found to be 8.35 per cent which was found insignificant and the co-efficient of variation was 56.08 per cent. The R^2 value 0.68 indicates that 68 per cent of the total variation was explained regarding the production of pigeonpea in Karnataka.

Growth rate of productivity under pigeonpea in different states of India for the period from 2007-08 to 2018-19 is represented in the Table 4. The productivity under pigeon pea in Maharashtra has been fluctuated from 922 MT per hectare in 2007-08 to 662 MT per hectare in 2018-19 with an average of 767.25 MT per hectare. The compound annual growth rate was found to be -0.47 per cent which was found insignificant and the co-efficient of variation was 22.18 per cent. The average productivity of pigeonpea in Karnataka for the study period was 608.25 MT per hectare with the

compound annual growth rate of 1.91 per cent which was found insignificant and the co-efficient of variation was 23.08 per cent. The average productivity under pigeon pea in Madhya Pradesh for the study period was 833.42 MT per hectare. The compound annual growth rate was found to be 5.80 per cent which was found insignificant and the co-efficient of variation was 31.29 per cent. The R^2 value 0.58 indicates that 58 per cent of the total variation was explained regarding the production of pigeonpea in Karnataka.

The instability indices for area, production and productivity for pigeonpea in Karnataka are 15.42 per cent, 25.89 per cent and 14.90 per cent, respectively. The growing of pigeonpea in Karnataka is not risky as the co-efficient of variation of area, production and productivity are 32.01 per cent, 45.84 per cent and 23.08 per cent, respectively. Hence, the Null hypothesis is rejected since there is instability in the area, production and productivity of pigeonpea.

The result concludes that the states like Karnataka, Madhya Pradesh, Gujarat, Jharkhand, Odisha and Chhattisgarh showed an upward trend in case of area, production and productivity of pigeonpea and the state

Table 4 : Growth rate of productivity under pigeonpea in different states

Sr. No.	Year	(kg/ha)										
		Maharashtra	Karnataka	Madhya Pradesh	Uttar Pradesh	Andhra Pradesh	Gujarat	Bihar	Jharkhand	Odisha	Chhattisgarh	Other states
1.	2007-08	922	712	670	891	652	1109	1012	800	825	522	897
2.	2008-09	600	528	804	914	456	989	1178	616	860	583	846
3.	2009-10	841	467	851	662	438	906	1514	871	841	510	791
4.	2010-11	750	594	337	898	383	986	1404	686	916	440	535
5.	2011-12	706	462	625	1044	301	1053	1514	904	812	433	441
6.	2012-13	819	555	662	1045	481	1184	2131	1034	912	620	641
7.	2013-14	906	713	716	900	561	995	1667	1043	896	614	645
8.	2014-15	600	651	981	606	503	1098	1438	1018	898	636	671
9.	2015-16	450	368	1079	691	600	1125	1577	903	886	458	560
10.	2016-17	1042	749	1133	1074	380	1156	1581	1002	884	598	714
11.	2017-18	909	861	1297	1175	430	1243	1548	1147	897	601	854
12.	2018-19	662	639	846	1084	182	1209	1852	1014	1022	480	748
	Total	9207	7299	10001	10984	5367	13053	18416	11038	10649	6495	8345
	Mean	767.25	608.25	833.42	915.33	447.25	1087.75	1534.67	919.83	887.42	541.25	695.40
	Std	170.19	140.37	260.74	182.34	129.09	103.40	286.93	156.48	54.20	75.68	139.94
	CV	22.18	23.08	31.29	19.92	28.86	9.51	18.70	17.01	6.11	13.98	20.12
	CAGR (%)	-0.47	1.91	5.80	1.66	-3.98	1.88*	3.41	3.89	1.13*	0.63	-0.40
	R^2	0.43	0.58	0.80	0.87	0.81	0.82	0.71	0.79	0.77	0.71	0.83
	Instability	16.81	14.90	14.06	7.13	12.55	4.02	10.05	7.78	2.94	7.53	8.30

Source: Ministry of Agriculture & Farmers Welfare, Govt. of India

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

like Andhra Pradesh showed negative growth rate in case of area, production and productivity of pigeonpea. Uttar Pradesh state showed positive trend in productivity and negative trend in case of area and production of pigeon. In case of Maharashtra showed positive trend in area and production but negative trend in productivity. Bihar showed significant positive trend in area and insignificant positive trend in productivity and insignificant negative trend in production of pigeonpea for the study period. The results are in similar with the Saraswathi *et al.* (2012) who reported that improvement management practices, higher income, better practices has direct link to the growth in area, production and productivity of major crops in Karnataka. And similar result was reported by Panwar *et al.* (2019).

The major growing areas of pigeonpea of Karnataka were Gulbarga, Bijapur and Bidar which contributes more than 70 per cent of area under pigeonpea when compared to the average area of Karnataka for the study period 2007-08 to 2018-19 which is presented in Table 5. The average area under pigeonpea in Gulbarga district was 376 thousand hectares which contributes about 45.20

per cent when compared to the average mean value of area under pigeonpea of Karnataka. The compound annual growth rate was found to be -2.40 per cent which was found insignificant and the co-efficient of variation was 22.91 per cent. The average area under pigeonpea in Bijapur district was 190 thousand hectares which contributes about 22.83 per cent when compared to the average mean value of area under pigeonpea of Karnataka. The compound annual growth rate was found to be 15.74 per cent with significant at 1 per cent level and the co-efficient of variation was 73.53 per cent. The average area under pigeonpea in Bidar district for the period was 71 thousand hectares which contributes about 8.54 per cent when compared to the average mean value of area under pigeonpea in Karnataka. The compound annual growth rate was found to be 1.38 per cent with significant at 5 per cent level and the co-efficient of variation was 8.36 per cent.

The major pigeonpea producing districts of Karnataka were Gulbarga, Bijapur and Bidar which contributes more than 80 per cent of production under pigeonpea when compared to the average area of

Sr. No.	Year	Gulbarga	Bijapur	Bidar	Raichur	Bagalkot	Koppal	Chitradurga	Tumkur	Bellary	Belgaum	Other districts
1.	2007-08	429.59	78.53	66.11	17.91	4.29	3.20	7.37	13.74	9.92	5.70	44.64
2.	2008-09	379.77	48.69	62.67	13.53	1.06	3.20	9.53	19.50	9.64	4.24	45.18
3.	2009-10	336.85	104.09	67.00	12.98	4.81	1.85	8.01	12.23	8.94	4.67	42.56
4.	2010-11	377.78	189.68	72.73	62.05	11.23	4.09	15.24	19.15	10.54	5.62	122.90
5.	2011-12	370.52	102.09	76.01	42.86	7.44	3.40	8.57	14.48	9.07	4.16	128.41
6.	2012-13	340.12	86.20	68.63	31.07	0.95	3.83	6.38	10.99	5.13	2.31	104.40
7.	2013-14	369.54	180.63	73.27	38.32	4.07	2.51	8.96	10.97	3.33	3.83	128.58
8.	2014-15	315.34	187.32	65.97	37.59	6.14	4.66	8.73	10.04	3.43	2.87	85.91
9.	2015-16	261.08	135.70	67.45	33.62	4.55	2.64	9.59	9.82	2.93	5.08	124.55
10.	2016-17	388.91	388.93	81.61	89.22	37.26	3.54	23.76	14.14	11.95	9.90	164.78
11.	2017-18	328.81	262.56	78.68	38.19	23.00	17.26	13.34	10.96	9.36	6.28	96.56
12.	2018-19	613.76	520.94	77.02	102.88	42.57	24.74	4.05	10.51	13.71	14.88	57.95
	Total	4512.07	2285.36	857.14	520.24	147.37	74.90	123.52	156.53	97.93	69.54	1146.41
	Mean	376.01	190.45	71.43	43.35	12.28	6.24	10.29	13.04	8.16	5.79	95.53
	Std	86.12	140.03	5.97	28.26	14.20	7.11	5.15	3.33	3.58	3.45	40.54
	CV	22.91	73.52	8.36	65.19	115.66	113.97	50.00	25.54	43.91	59.56	42.43
	CAGR(%)	0.49	17.49**	1.54*	14.53**	24.93*	15.23*	0.75	-3.96**	-1.53	6.58	6.59
	R ²	0.84	0.85	0.79	0.72	0.84	0.96	0.68	0.58	0.82	0.88	0.78
	Instability	9.05	28.57	3.81	34.74	46.27	22.79	28.28	16.55	18.63	20.63	19.90

Source: Directorate of Economics and Statistics of India, Bengaluru

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

Karnataka for the study period 2007-08 to 2018-19 which is presented in Table 6. The average production under pigeonpea in Gulbarga district was 289 thousand MT which contributes about 55.47 per cent when compared to the average mean value of production under pigeonpea of Karnataka. The compound annual growth rate was found to be 2.66 per cent which was found insignificant and the co-efficient of variation was 52.73 per cent. The average production under pigeonpea in Bijapur district was 105 thousand MT which contributes about 20.15 per cent when compared to the average production under pigeonpea of Karnataka. The compound annual growth rate was found to be 22.58 per cent with significant at 1 per cent level and the co-efficient of variation was 86.61 per cent. The average production under pigeonpea in Bidar district for the period was 61 thousand MT which contributes about 11.70 per cent when compared to the average production under pigeonpea in Karnataka. The compound annual growth rate was found to be 1.63 per cent which was found insignificant and the co-efficient of variation was 47.47 per cent.

In case of productivity of pigeonpea in major districts

of Karnataka for the study period 2007-08 to 2018-19 which is presented in Table 7. The average productivity under pigeonpea in Gulbarga district was 0.75 tonnes per hectare with compound annual growth rate of 5.18 per cent which was found insignificant and the co-efficient of variation was 42.89 per cent. The average productivity under pigeonpea in Bijapur district was 0.52 tonnes per hectare with compound annual growth rate of 5.86 per cent which was found insignificant and the co-efficient of variation was 40.46 per cent. The average productivity under pigeonpea in Gulbarga district was 0.85 tonnes per hectare with compound annual growth rate of 0.25 per cent which was found insignificant and the co-efficient of variation was 41.46 per cent.

The result depicted that the districts like Bijapur, Bidar, Raichur, Koppal, Chitradurga, Davangere, Belgaum, Bagalkot and Kolar has shown an upward trend and the districts like Gulbarga, Tumkur, Bellary and Mysore showed declining trend in terms of area under pigeonpea. The districts like Gulbarga, Bijapur, Bidar, Raichur, Chitradurga, Davangere, Belgaum and Bagalkot has shown an upward trend and the districts like Tumkur,

Sr. No.	Year	Gulbarga	Bijapur	Bidar	Raichur	Bagalkot	Koppal	Chitradurga	Tumkur	Bellary	Belgaum	Other districts
1.	2007-08	302.82	34.39	48.42	6.25	3.40	1.69	4.94	11.39	5.40	2.35	63.96
2.	2008-09	187.61	19.29	50.78	3.43	0.29	2.80	4.28	13.56	4.85	1.72	26.39
3.	2009-10	153.29	31.05	49.65	3.63	2.61	1.51	4.64	7.10	3.30	1.42	23.81
4.	2010-11	206.72	107.22	65.57	20.99	5.71	7.50	10.89	5.60	4.37	1.96	92.49
5.	2011-12	176.00	38.60	44.84	11.81	1.92	5.21	5.23	4.87	2.99	1.64	60.90
6.	2012-13	250.74	50.69	82.67	12.10	0.21	4.42	4.17	3.10	1.80	1.17	44.76
7.	2013-14	394.59	170.56	59.31	16.97	2.13	1.90	7.25	4.24	1.61	1.65	72.70
8.	2014-15	210.00	114.78	44.24	24.93	2.67	4.93	7.21	2.34	1.32	2.32	59.26
9.	2015-16	94.99	39.58	29.80	14.25	1.26	1.82	9.58	3.38	1.04	1.14	45.17
10.	2016-17	541.64	330.32	101.49	70.27	29.24	0.97	6.57	3.01	7.04	7.30	18.97
11.	2017-18	377.65	159.64	129.91	27.10	15.97	9.82	10.10	2.87	7.69	4.28	17.26
12.	2018-19	569.08	167.27	34.83	36.26	19.33	6.72	1.81	3.57	9.17	7.72	92.24
	Total	3465.12	1263.39	741.50	247.97	84.74	49.28	76.65	65.03	50.59	34.65	617.92
	Mean	288.76	105.28	61.79	20.66	7.06	4.11	6.39	5.42	4.22	2.89	51.49
	Std	152.27	91.19	29.33	18.50	9.31	2.82	2.74	3.58	2.69	2.31	26.64
	CV	52.73	86.61	47.47	89.53	131.84	68.58	42.88	66.10	63.90	80.07	51.74
	CAGR (%)	2.66	22.58**	1.63	28.03**	16.11	-3.79	5.58	-15.89**	-9.50	5.59*	-2.19
	R ²	0.61	0.51	0.86	0.61	0.73	0.57	0.53	0.95	0.91	0.75	0.76
	Instability	32.93	60.63	17.76	55.91	68.51	44.97	29.40	14.78	19.17	40.04	25.35

Source: Directorate of Economics and Statistics of India, Bengaluru

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

Table 7 : Growth rate of productivity under pigeonpea in major districts of Karnataka												(kg/ha)
Sr. No.	Year	Gulbarga	Bijapur	Bidar	Raichur	Bagalkot	Koppal	Chitradurga	Tumkur	Bellary	Belgaum	Other districts
1.	2007-08	704.90	437.96	732.45	348.65	792.27	527.39	670.65	828.43	544.32	411.43	1432.97
2.	2008-09	494.00	396.15	810.35	253.64	272.73	875.94	449.39	695.39	503.53	404.77	584.08
3.	2009-10	455.05	298.30	741.00	279.27	542.51	815.33	578.51	580.42	369.55	304.86	559.51
4.	2010-11	547.20	565.25	901.55	338.21	508.24	1836.27	714.42	292.62	414.17	347.68	752.59
5.	2011-12	475.00	378.10	589.95	275.51	257.50	1531.31	610.83	336.28	329.69	393.27	474.29
6.	2012-13	737.20	588.05	1204.60	389.51	220.23	1154.35	652.62	282.13	351.47	504.32	428.72
7.	2013-14	1067.80	944.30	809.40	442.70	522.58	756.19	809.42	386.65	485.41	430.36	565.42
8.	2014-15	665.95	612.75	670.70	663.11	435.06	1058.41	825.50	232.77	384.88	809.34	689.76
9.	2015-16	363.85	291.65	441.74	423.70	277.33	688.66	999.37	343.85	355.17	225.22	362.65
10.	2016-17	1392.70	849.30	1243.55	787.55	784.71	274.58	276.44	212.77	588.98	737.24	115.14
11.	2017-18	1150.00	610.00	1650.00	710.00	690.00	570.00	760.00	260.00	820.00	680.00	178.70
12.	2018-19	930.00	320.00	450.00	350.00	450.00	270.00	450.00	340.00	670.00	520.00	1591.88
	Total	8983.65	6291.80	10245.30	5261.84	5753.14	10358.42	7797.15	4791.32	5817.18	5768.50	7735.69
	Mean	748.64	524.32	853.77	438.49	479.43	863.20	649.76	399.28	484.76	480.71	644.64
	Std	321.09	212.16	354.00	181.08	201.11	472.67	195.73	195.96	150.24	178.44	447.44
	CV	42.89	40.46	41.46	41.30	41.95	54.76	30.12	49.08	30.99	37.12	69.41
	CAGR(%)	5.18	5.86	0.25	10.45*	-0.69	-5.42	-0.10	-11.99**	-0.60	4.28	-14.55
	R ²	0.60	0.46	0.82	0.81	0.56	0.78	0.31	0.93	0.91	0.42	0.97
	Instability	27.26	29.79	17.54	18.24	27.83	25.68	25.02	12.98	9.30	28.27	12.02

Source: Directorate of Economics and Statistics of India, Bengaluru.

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

Koppal, Bellary, Kolar and Mysore showed declining trend in terms of production under pigeonpea. The result also depicted that the districts like Gulbarga, Bijapur, Bidar, Raichur, Koppal and Belgaum has shown an upward trend and the districts like Tumkur, Bellary, Chitradurga, Davangere, Bagalkot, Kolar and Mysore showed declining trend. Thus, there is a need to take up productivity enhancing measures in pigeonpea like varietal improvement, improved cultural practices, disease control measures and irrigation facilities. The findings are similar with Parthiban *et al.* (2019) in the study of trend analysis of area, production and productivity of groundnut and estimation of cost of production in Tiruchirappalli district

Conclusion:

This study has analyzed the trend in area, production and productivity of pigeonpea and the instability by Cuddy Della Valle index. The growth rate of area and production of pigeonpea in India showed significant positive trend at 1 per cent and 5 per cent level, respectively and productivity showed insignificant positive trend which

indicates less risk in growing pigeonpea in future. The growth rate of area and production of pigeonpea of Karnataka showed significant positive trend at 5 per cent level and productivity showed insignificant positive trend. The increase in production occurs due to increase in area as well as interactions of area and productivity of pigeonpea in the study period. Thus, there is a need to take up productivity enhancing measures in pigeonpea like varietal improvement, improved cultural practices, disease control measures and irrigation facilities. The instability indices for area, production and productivity for pigeonpea is positive which indicates less risk in growing pigeonpea in future.

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